SYMPOSIUM PROCEEDINGS

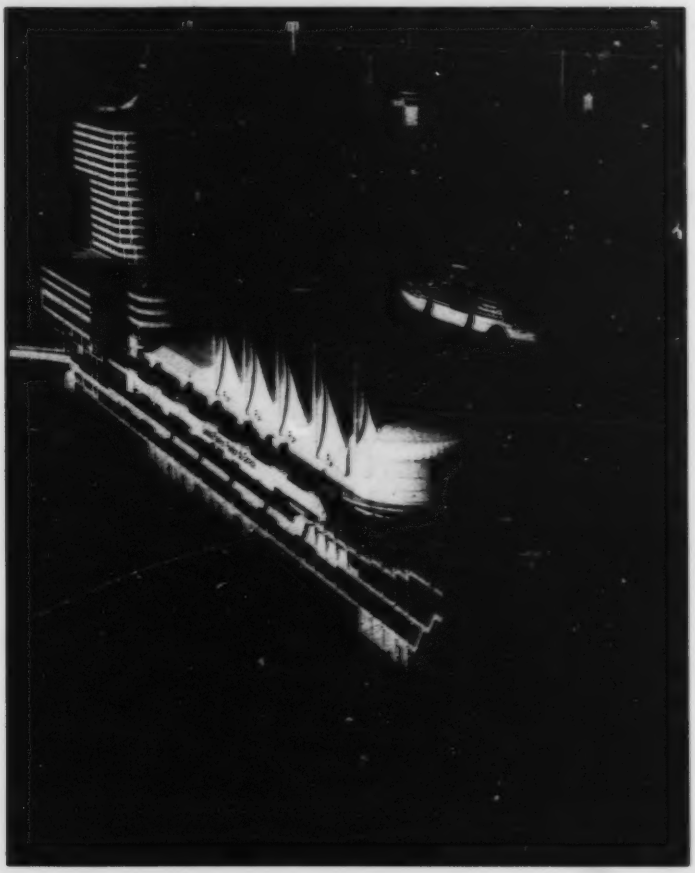
GIS 89

Vancouver, Canada

MARCH
7 - 10
1989

"A WIDER PERSPECTIVE"

GIS '89, an International Symposium on Geographic Information Systems, is co-sponsored by Forestry Canada and Reid, Collins and Associates.



Reid, Collins

Forest Resource Consultants

Forestry Canada Forêts Canada

FRDA REPORT 076

GIS'89 - A WIDER PERSPECTIVE : PROCEEDINGS

Contractor

Reid Collins and Associates
(A Division of H.A. Simons Ltd.,)
1550 - 401 West Georgia Street
Vancouver, B.C.
V6B 5A1

Departmental Representative

Art Shortreid
Pacific Forestry Centre
Forestry Canada
506 West Burnside Road
Victoria, B.C.
V8Z 1M5

March 1989

This report has been reviewed by Forestry Canada and approved for distribution. Approval does not necessarily signify that the contents reflect the views and policies of Forestry Canada. Mention of Trade names or commercial products does not constitute recommendation or endorsement for use.

ISSN 0835-0752

SYMPOSIUM PROCEEDINGS

"A WIDER PERSPECTIVE"

GIS '89, an Internationa. Symposium on Geographic Information Systems, is co-sponsored by Forestry Canada and Reid, Collins and Associates.

This volume contains the text of papers presented at GIS '89, arranged alphabetically by author.

Plenary Sessions

1 - GIS In The Forestry Sector
2 - Do We Need GIS ?
3 - Applying GIS Technology In The Developing World
4 - Future Role of GIS in Forestry: User's Perspective

Concurrent Sessions

1 - Administrative Issues
2 - Implementation
3 - Justifying a GIS
4 - Data Issues 1: Alternate Data Sources
5 - GIS - Its Role in Management Decision-Making
6 - GIS Applied to Operations
7 - Project Management - Successful Implementation
8 - Data Issues 2: Ensuring GIS Longevity
9 - GIS in Government
10 - Future of GIS: Where is the Technology Taking Us?

89-06178/

GIS'89 is co-sponsored by Forestry Canada and Reid, Collins and Associates, a division of H.A. Simons Ltd., with funding provided under the Canada-British Columbia Forest Resource Development Agreement, and is supported by the following agencies:

Alberta Forestry, Lands and Wildlife
American Society for Photogrammetry and Remote Sensing
Applied Science Technologists and Technicians of British Columbia
Association of British Columbia Professional Foresters
British Columbia Forestry Association
British Columbia Institute of Technology
Canadian Cartographic Association
Canadian Institute of Forestry
Council of Forest Industries of British Columbia
Geomatics Industry Association of Canada
Province of British Columbia, Ministry of Crown Lands
Province of British Columbia, Ministry of Economic Development
Province of British Columbia, Ministry of Forests
University of British Columbia
University of Victoria
Urban and Regional Information Systems Association

GIS'89 Steering Committee

Michael Heit
Symposium Co-Chairman
Senior Program Director
Forestry Development
Forestry Canada
Victoria, B.C.

Martin Vennesland
Symposium Co-Chairman
President
Reid, Collins and Associates
Vancouver, B.C.

Art Shortreid
Technology Transfer and Development Officer
Forestry Canada
Victoria, B.C.

Jim McPhalen
Chairman, Technical Program Committee
Consulting Forester
Vancouver, B.C.

Bardolf Paul
Manager
Marketing and Sales
Reid, Collins and Associates
Vancouver, B.C.

Paddy O'Reilly
Symposium Planner
GIS'89
Vancouver, B.C.

Roger Baiser
Surveys and Mapping Branch
Ministry of Crown Lands
Victoria, B.C.

John Barker
Manager
Forestry Technical Services
Western Forest Products Limited
Vancouver, B.C.

Charles Goodbrand
Program Head
Spatial Information Systems
British Columbia Institute of Technology
Burnaby, B.C.

John Harrower
Director
Resource Evaluation Branch/
Land Information Branch
Alberta Forestry, Lands and Wildlife
Edmonton, Alberta

Norm Shaw
Assistant Instructor
Forest Resource Section
British Columbia Institute of Technology
Burnaby, B.C.

GIS'89 and GIS'90
Symposium Office
134 Abbott Street
Suite 303
Vancouver, B.C.
Canada V6B 2K4

Tel: (604) 688-0188
Fax: (604) 682-2987

June 1, 1989

Dear Colleagues:

It is with great pleasure that we present the Proceedings of GIS'89 - "A Wider Perspective". This highly successful event attracted 800 participants to the Vancouver Trade and Convention Centre, and included over 30 exhibitors at a concurrent Trade Show. Over 300 people attended the four day-long pre-symposium workshops and more than 200 participated in vendor-hosted hands-on tutorials throughout the Symposium. It was, as they say in show business, a hit!

As Co-Chairmen of GIS '89, we would like to take this opportunity to acknowledge the following individuals and organizations for their contributions to the success of the event:

> The planning and management team from Reid Collins and Associates, headed by Bardolf Paul and managed by Paddy O'Reilly. We wish to recognize their outstanding dedication in bringing GIS'89 from the initial concept to unqualified success; Jim McPhalen for chairing the Technical Committee responsible for organizing and delivering an informative and interesting program; all volunteer members of the Steering and Technical Committees for their input, advice, suggestions and hard work on behalf of GIS'89; staff from both Forestry Canada and Reid Collins and Associates for their unqualified help whenever and wherever it was required; and finally, all of the speakers, moderators and exhibitors for their timely and topical presentations and professional exhibits, without whom this Symposium would not have been possible.

We are committed to GIS'90 in Vancouver on March 13-16, 1990. Our theme for this event is: "MAKING IT WORK", and we would appreciate your input into the program. Drop us a line with your thoughts - we appreciate the feedback be it positive or negative.

See you at GIS'90!

Michael J. Heit
Co-Chairman - GIS'89
Forestry Canada

Martin Vennesland
Co-Chairman - GIS'89
Reid Collins and Associates

"A WIDER PERSPECTIVE"

Edited by

JIM McPHALEN

Consulting Forester
Chairman, GIS'89 Technical Program Committee

in collaboration with

Paddy O'Reilly
GIS'89 Symposium Director

Melva Bradshaw
Reid Collins and Associates

(c) Copyright reserved 1989

Notes

This publication contains the text of papers presented at GIS'89 that were submitted for publication. Where complete papers were not available, an abstract only is published. Papers that were available prior to February 19, 1989 were distributed at the Symposium to stimulate discussion . Papers too late for inclusion in the earlier proceedings have been added to this volume, and , with the exception of the Minister's Opening Remarks, appear at the end of the volume.

Papers were produced from disks, hard copy and graphics prepared by authors and no responsibility is accepted by the organizers of GIS'89 for any errors or omissions in their content.

CONTENTS

MESSAGE FROM THE CO-CHAIRMEN

INFORMATION FOR THE FORESTRY EQUATION *Hon Frank Oberle*

APPLICATIONS: THE DESIGN IMPERATIVE *John C. Antenucci* 1

SIGN UP OR SIGN OFF: GAINING AND MAINTAINING SUPPORT FOR GIS *John C. Antenucci* 7

SCANNING - AN ALTERNATIVE MEANS OF SPATIAL DATABASE CONSTRUCTION *David H. Armstrong* 13

TERRAIN RESOURCE INFORMATION MANAGEMENT (TRIM): A STANDARDIZED GEO-REFERENCING DATABASE FOR THE PROVINCE OF BRITISH COLUMBIA *Roger Balser* 23

GIS FROM A MANAGER'S PERSPECTIVE: PROBLEMS AND PROSPECTS *John Barker* 29

COMPUTERIZATION OF NATURAL RESOURCE INFORMATION IN THE NATIONAL PARKS OF WESTERN REGION *Patricia Benson* 31

A FRAMEWORK FOR INTEGRATING SILVICULTURE SURVEY WITH DATA ANALYSIS, PLANNING, AND DATABASE UPDATE *David G. Brand* 35

USING GIS TO IDENTIFY AGRICULTURAL SOILS SUSCEPTIBLE TO SALINITY DEVELOPMENT - Poster *Dennis L. Corwin* 41

GIS - IS IT COST-EFFECTIVE?: A CASE STUDY *Don Couch* 43

INTEGRATION OF GIS AND PHOTOGRAMMETRY *Al Daykin* ..... 47 *and* 225

THE FOREST RESOURCE ANALYSIS SYSTEM: A GIS-BASED DECISION SUPPORT SYSTEM *Lois H. Dellert* 49

HARVEST PLANNING WITH A GEOGRAPHIC INFORMATION SYSTEM *Duane R. Dippon, Robert Wright and Robert Metzger* 55

REFINEMENT OF A MODEL USED TO INTEGRATE THE MANAGEMENT OF DEER AND FORESTS - Poster *Marvin A. Eng, R. Scott McNay and Rick E. Page* 65

A TECHNICAL AND OPERATIONAL COMPARISON OF GEOGRAPHIC INFORMATION SYSTEMS AS APPLIED TO THE CANADIAN FOREST INDUSTRY *Eric (Alex) Ferguson* 67

EDUCATIONAL AND GEOGRAPHICAL INFORMATION SYSTEMS *C.Goodbrand* 69

GIS - THE SASKATCHEWAN EXPERIENCE *Fern Gruszka* 75

THE ROLE OF GIS IN PROVINCIAL INVENTORIES *Frank Hegyi* 85

THE PRACTICAL APPLICATION OF GIS IN FOREST RESOURCE MANAGEMENT *Chris Hermansen* 89

DATA CONSIDERATIONS - SOME PRINCIPLES FOR ACCURACY AND RELIABILITY OF DATA IN A GIS SYSTEM *Kim Iles* 103

NATIONAL GEOMATICS DATABASES OF CANADA *Zul Jiwani and G. Plunkett* 105

FORESTRY, REMOTE SENSING AND WORKSTATIONS: PRESENT STATE AND FUTURE TRENDS *W. M. Johnstone and S.H. Paine* 111

MAKING GIS WORK IN FOREST MANAGEMENT *Glen A. Jordan* 115

APPLICATION OF GIS AT THE DIVISIONAL LEVEL: GEOGRAPHIC INFORMATION SYSTEMS OR GARBAGE INDUCTION SYSTEMS? *Jack Lavis* 121

SO YOU BOUGHT A GIS - NOW WHAT? *Allan G. Levinsohn* 125

GIS: PICTURE OR PUZZLE PIECE? *Jim McDougall* 133

GIS, AN EVOLVING TECHNOLOGY: WHEN DO I JUMP IN ? *Alex Miller* 143

HARVEST PLANNING ON A MICRO-BASED GIS: A DESCRIPTION OF THE MINISTRY OF FORESTS' "HARVEST MANAGEMENT SYSTEM" *Andrew Mitchell* 145

GEOGRAPHIC INFORMATION SYSTEMS IN DEVELOPMENT PLANNING: A WORLD BANK PERSPECTIVE *Glenn Morgan* 151

DATA INTEGRITY - MANAGING DATA FOR THE FUTURE *Reeler, E.C. and Masry, S.E.* 161

CREATION OF FOREST INVENTORY MAPS USING AIRBORNE DIGITAL IMAGERY AND GIS - Poster *N. Reid and J. Fisher* 165

TRAVELING DOWN THE YELLOW BRICK ROAD TOWARDS INTEGRATED RESOURCE INFORMATION SYSTEMS *Don Reimer* 167

GIS-BASED DECISION SUPPORT SYSTEMS: A FOREST INDUSTRY PERSPECTIVE *Thomas W. Reisinger* 171

HIMALAYAN-SCALE PROBLEMS AND MICRO-GIS SOLUTIONS *H. Schreier, P.B. Shah, M. Schmidt and G. Kennedy* 179

THE ULTIMATE COMPROMISE: SITUATING GIS IN THE ORGANIZATIONAL HIERARCHY *James L. Smith, Stephen P. Prisley* 185

INFORMATION SYSTEMS: A FOREST PRODUCTS PERSPECTIVE *W. Thomas* 191

GIS IN THE NORDIC COUNTRIES: Market and Technology/Strategy for Implementation - A Nordic Approach/Applications of GIS to Forestry and Natural Resources - Norway *Svein Tveitdal* 201

GIS - A TOOL IN FOREST PEST MANAGEMENT *G.A. Van Sickle* 213

DEVELOPING A NEW GIS - EVOLUTION OR REVOLUTION? *R. R. Wakeley* 221

JUSTIFICATION FOR GIS/MIS *David Wills* 223

INTEGRATION OF GIS AND PHOTOGRAMMETRY *Al Daykin* 225

TEXT OF AFTER-LUNCH SPEECH *Chuck Lankester* 229

A WIDER PERSPECTIVE - CONFERENCE SUMMARY SPEECH *Warde Shearing* 237

INFORMATION FOR THE FORESTRY EQUATION

The Honourable Frank Oberle

Minister of State (Forestry)

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLIUMBIA
MARCH, 1989

OPENING ADDRESS

To those of you who are visiting Canada for the first time -- on behalf of the Prime Minister and my colleagues in Cabinet, I offer a most sincere welcome. To those of you from elsewhere in Canada who are enjoying the many benefits which B.C. has to offer, my consolations that you don't live here year-round.

Someone has told me when this Symposium draws to a close, the combined brilliance and ingenuity of you who have gathered here will be the world's most up-to-date databank on the application of geographical information systems to forestry and other resource sectors. So, it is a privilege and pleasure for me to be here with such an important group.

As many of you know, I have come to my posting as a Minister of Forestry after three years as Minister for Science and Technology. In that role, I helped shape Canada's future by ensuring we would be able to stay on the leading edge of information technologies as we entered the 21st century.

In my previous incarnation as Science Minister, I was able to convince my colleagues that Canada did not have to choose between high tech and resource industries -- the secret would be to apply the result of scientific discovery and technological innovation to become the world's best foresters.

That's why I'm so pleased to see that one of the hottest areas of modern information technology is being focussed on forestry, one of Canada's oldest industries.

Thanks to your innovative spirit, Canadian forestry can keep on top while the global marketplace shifts dramatically beneath our feet.

All of us surely sense that the potential is tremendous -- but I don't think anyone can foresee just how far and just where it is all going. The whole field is expanding so rapidly and yielding such unexpected synergistic results from encounters with other technologies that I think this event will be something to recount to your grandchildren when you tell them of your pioneering efforts way back in 1989.

Today's fantasies become tomorrow's reality. We can dream of cruisers on the line in the remotest parts of Canada, comparing their field observations with site-specific information and maps which appear on their portable computers screens. They would send their fresh data back to the base by satellite, and maybe later that same day, analysts and policymakers in Ottawa, Vancouver and Toronto would use that information to make informed decisions. And that will only be the next generation of "CAC" -- "Computer-Assisted Cruising!" The cruiser himself may well become obsolete as we perfect our remote sensing technology and apply it to managing our forests.

Making fantasies like these possible gives Canada important economic opportunities -- to export and trade in the hardware and software, and the training of highly-qualified personnel that would be required and employed around the world. The sky is the limit for scenarios such as this and we in Canada are leading the world in some of the critical areas that show best promise of reaching and extending these limits.

This, of course, did not happen by accident. Canadians have always been conscious of our custodial responsibilities over the vast storehouse of resources which are our heritage. Our forests have become part of the Canadian psyche. We have come to love and feel protective of the ecosystems which sustain us.

So, I take great comfort in your expertise, and you can take considerable comfort in knowing that forestry research and development is regarded as a national priority by both federal and provincial governments.

I look to you for assistance in raising public consciousness -- that your work is crucial to our future success, and that it is a high-yield investment which will increase our productivity and enhance our socio-economic prospects.

As you know, some people around the world -- and even some of our own citizens -- have the perception that in

image of Canada's past--but they, as well, want us to strive for a modern image, one which stresses the intellectual wealth we have accumulated, and which must be enhanced as well to meet the challenges of a new age.

I hope you will take up this challenge with me -- the challenge of showing public and politicians alike the great opportunity we have of linking high tech with forestry -- be it biotechnology or information technologies -- and demonstrating to them the importance of forging these linkages.

Canada is a trading nation -- but our trading is not like that of Japan or Germany. We export both high tech products and products that are made from the conversion of our natural resources. In the former we succeed best with products which we developed to address our special needs, products we needed to turn adversity into opportunity -- for example, communications over long distances, machines which can cope with harsh climates, aircraft and vehicles especially suited to obtain access to remote and isolated regions.

But it is the latter category of products -- those originating with our natural resources -- which has brought us wealth and prosperity, and which with intelligent planning, will continue to secure our future.

Our new ambassador to the United States, Derek Burney, pointed out in a recent speech just how important is our $15-billion-a-year forest products trade in comparison with other commodities. If we take all Canadian exports to Britain -- our forest exports are seven times greater. They're fifteen times greater than all Canadian exports to France. And they're about equal to the total of all Canadian exports to all other countries of the world. Over 300 cities and towns throughout Canada -- entire regions of our country -- rely solely on our forests for their economy and well-being.

This helps you to understand why we in Government have made huge commitments and investments in recent years to assure a sustained yield from our forests and to maintain a strong, vibrant and dynamic forest industry.

And having told you of my enthusiasm in linking Paul Bunyon with computers and lasers, you can understand my high expectations for your endeavours. If we are to be successful, of course, geographic information must be available to a variety of end users who are experts in their own field but who may have little knowledge of yours.

We are agreed that the best prospect for expanding the benefits of our forests lies in management of the resource -- and increasingly, information is the key element of good management. You will find a great deal of support for any effort or technology which can provide accurate information on forestry and resources -- the Auditor-General demands it and the public is demanding it, not to mention businesses which seek the competitive edge by careful planning.

Another key to Canada's success will be cooperation. Most of you who work in the industry probably know of the national forest sector strategy which manifests itself through the forest resource development agreements between the federal and provincial governments. We are about to re-negotiate these accords, and you might be interested to know that among my priorities and biases with which I will approach the negotiations is the extension of our planning horizons much further into the future than is now the case -- 20 years vs. 80 years. As well, I would like such planning to include both commercial fiber and non-timber values. And naturally, I will insist that we pay more attention to research.

But above all, it is absolutely necessary that we have a more reliable database, more accurate information which is site specific in terms of the mix of species, annual growth rates, etc. This is critical for rational and effective planning.

With these as my priorities, you can again understand my strong interest in the potential of geographic information systems. I don't pretend to share your expertise, but it seems to me that if we are to ever achieve the kind of national inventory data which we need there will have to be some kind of standardization of basic data on which we can make our assumptions, develop and measure our standards of performance, develop our expert systems, and so on.

A national geographic information database must be accessible by industry, government and non-governmental public interest groups in every part of Canada. I hope I can persuade the provinces to agree with me that the next set of agreements could set into motion a process through which this standardization could be achieved.

You noticed I mentioned non-government public interest groups. It is essential that they, too, have access to factual information. There has been a fundamental change in public attitudes toward forestry. The Canadian people are expressing increased concern about our forests, and they are insisting that their forest heritage is managed wisely and serve a multiplicity of purposes. Society's needs for non-timber values will only increase over time, and the pressures will increase. One pollster rated the environment as "potentially the most explosive issue, and certainly the issue of the future". That has to be put into the forestry equation. And we must work together to ensure that public opinion and attitudes are formed -- from a basis of good information and rational discussion -- instead of the emotional debate that is shaping it now.

The fact that people are more conscious and concerned about the deterioration of the environment, about scarred landscapes and poisoned water and air, does not mean that they would not be prepared to have their energies and concerns translated into practical and productive policies.

I look forward to the contribution of geographic information systems so that we can reach consensus in Canada on policies and direction that is required of us as custodians of a vital heritage.

I look to you to play a very key role through the gathering, analyzing and providing access to the information that will allow us to make the right choices between economic development and environmental protection, the right balance between economic benefits and social returns, the right balance between the claims of this generation and those of future generations.

So, I ask for your help, and I offer to you the cooperation of the Federal Government in furthering your work. Through our respective efforts, we can ensure that society and industry alike have the necessary information to adopt forestry policies and practices which secure our nation's future.

I wish you well in your deliberations and success in your endeavours.

APPLICATIONS: THE DESIGN IMPERATIVE

John C. Antenucci

President
PlanGraphics, Inc.
202 West Main Street, Suite 200
Frankfort, Kentucky 40601-1806
(502) 223-1501

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

For those organizations evaluating GIS hardware, software, and data conversion services, it can become confusing to compare products and services from different vendors when the focus is on detailed technical issues alone. The technical issues important in the acquisition and implementation of a GIS are extremely complex. System evaluation based on a sound definition of applications can provide the focus for the preparation of system specifications and review the responses from vendors. The definition of applications with a clear statement of priorities, data requirements and users affected provides a framework for preparing a logical implementation plan. This paper explores the application-definition process and its role in system procurement and GIS implementation.

APPLICATIONS: THE DESIGN IMPERATIVE

Whether recognized or not, designing geographic information systems involves both technical and institutional challenges and opportunities. There is a track record of misfires, near misses, and potential successes to challenge the newcomer and the professional. There's a certain logic involved in GIS design, though by no means does the science dominate the art.

Sorting needs from embellishments is central to making progress. Certainly, much is possible with the technology of today (irrespective of that of tomorrow). Yet, human nature, aided and abetted by an industry's aggressive marketing, tempts both the experienced and inexperienced to take on too much, too quickly. Attracted by the glitter and promises, practicalities are ignored along with budget, human resources, or time. These are the experiences of those who have seen success and who have fallen short - lessons learned. Experiences that set a pattern for those *getting started.*

CONTRAST AMONG SYSTEMS

Geographic information management technology embodies a broad diversity of capabilities. Like users, organizations relying on geographic information have an equally diverse range of needs for the information and the support that the technology can provide. Identifying the aspects that are essential to an organization is fundamental to implementation. Recognizing the variances in the available technology is equally important.

There is now a wide range in the capabilities and capacities among automated mapping and geographic information systems. They range from simple microcomputer drafting to very sophisticated geographic analysis systems.

One of the most obvious contrasts is the distinction between mere drafting and GISs. Some systems are limited to interactive graphics, either because of their capacity or the design philosophy of the developer. These systems are designed to optimize the efficiency of graphic storage and manipulation. They tend to have very high-quality, quick, powerful, and easy-to-use graphic entry, manipulation, and display capabilities.

Other systems have very sophisticated geographic analysis capabilities, including fast, large-capacity polygon overlay analysis; street network and utility system analysis; and powerful attribute linkage, retrieval, and display functions for use in geographic analysis. These systems generally provide graphic processing though, in some cases, they are not as efficient as the systems that are dedicated to graphics.

Another contrasting view comes from the perspective of the computer processor or platform. There is a wide range in the size and type of processor on which automated mapping and GISs operate. A GIS operates on large mainframe computer systems, which provide capacity for storage and processing of both map graphic and attribute data on the same system. At the other end of the spectrum are numerous microcomputer systems that have become widely available.

Between these extremes lie most of the currently operating systems. They are implemented on minicomputers, which provide powerful interactive graphics processing and geographic analysis capabilities. The systems have large capacity and are generally dedicated to the geographic functions. Increasingly, linkage is established with mainframe systems to obtain attribute data for processing with related map features.

A more recent phenomena is the emergence of the "engineering" workstation as a keystone in GIS installations. The workstations provide exceptional processing speeds, significant internal storage and the potential for accessing, at high transfer speeds, large volumes of external data.

Data structures vary among systems with major contrasts between drafting and the geographic analysis systems. The former employ structures that are particularly efficient for processing graphics and retrieval of graphic data. The GISs, on the other hand, are often optimized for linkage of graphic and attribute data and for spatial analyses. Prominent features of these systems are topological data structures and relational database management systems.

Institutional differences influence the choice of system functionality, hardware platform and configuration, and database content and a structure. The mandates and missions of the organizations certainly influence the technology chosen. However, traditional affiliations with specific vendors, short-term objectives and funding, and organizational biases and turf frequently dominate the decisions leading to a GIS solution.

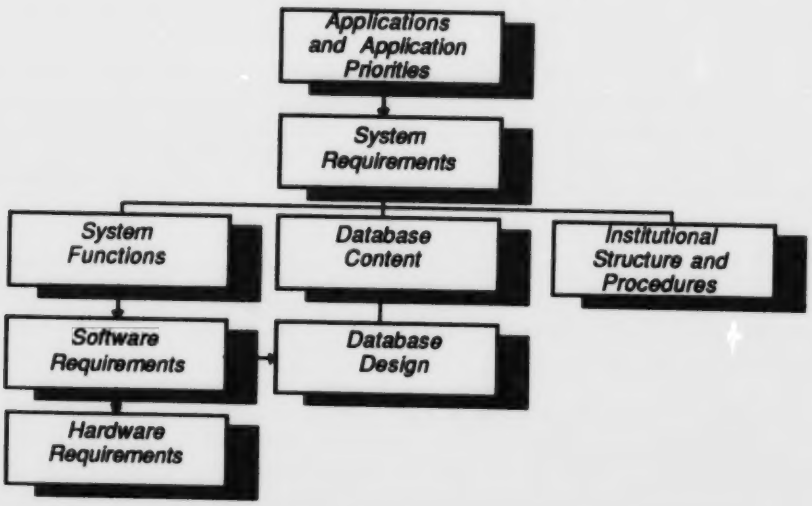
GIS DESIGN PHILOSOPHY

Introduce the normal inertia to change that is latent in most organizational structures and the opportunity that GIS presents becomes a challenge. Over the past decade a model has emerged that offers structure to proceeding with the design and implementation of a GIS. Precedent to its use, however, support must be garnered to overcome the inertia. And as a precedent to support, a clear vision of the role of the GIS within the organization must form.

A consistent philosophy leads to a clear vision of GIS utility, a philosophy that *Applications Must Drive System Design*.

"System" entails more than hardware and software components. The system certainly incorporates those elements. As importantly, system embodies database content and structure, personnel, organizational structure, and financial resources. Figure 1 illustrates the relationship between the key elements.

FIGURE 1
APPLICATIONS DRIVE DESIGN



Requirements of a GIS should be defined in terms of the applications the system is expected to support. As noted above, and as will be detailed in later chapters, the technology offers a diversity of potential, not all of which is best available from a single source. By thoroughly identifying the applications that the user organization(s) must support, and by establishing the relative priorities of each, a cogent definition of the System can emerge.

System functionality, database content, and institutional structure and procedures are equal derivatives of the system requirements. Too often hardware and software become the dominant or exclusive focus of GIS decisions.

The database is inherently critical to performing any application. Whether the database will be built transactionally, over a period of time, or, as is more often the case, the result of a substantial front-end effort, its content and accuracy are essential to the success of GIS. As importantly, the cost of database development and maintenance

exceeds the costs of all other GIS components by several multiples. Defining database content and accuracy, while reflecting the priorities of the applications, is an important first step in system design.

Though detailed database design is obviously of critical importance to system implementation, it is not an essential element to getting started. Furthermore, detailed database design is dependent on software considerations which are determined later in the process.

The functionality of the system can be expressed without focusing on select software and hardware products. The graphic and database manipulations, the analytical functions, and system configuration are elements of system functionality. By defining these elements, the character of the system takes form and cost estimation becomes possible. During this effort, and within the context of the chosen applications, the relative importance of various system functions is determined. Should the system be optimized for the entry of drawings or maps? Will the manipulation of graphic data more likely involve the combination of various themes best represented by polygons, or will it be the movement and placement of lines and dimensions? Will the linear features be schematic representations or accurately depict placement? Will linear features be used in a manner that their connectivity is essential, desirable, or unimportant?

Is it important that multiple individuals have immediate access to graphic representations of the database? Can the user community best be served by a central service, and therefore, an equipment configuration that is powerful and centralized? Will the equipment be used to support other processing functions that are non-spatial? These and other queries form the basis of a conceptual system configuration which may be accommodated by multiple vendors.

Specific decisions on software and hardware are not a precedent to getting started. In fact, premature focus on either can orient the design away from solutions that are more responsive to system requirements.

The presentation of computer hardware as a subordinate to software is intentional. Once one or more software packages are identified as supporting the application requirements in an advantageous manner, compatible computer processors and operating systems can be chosen. With the increased availability of UNIX and associated technology, the transferability of software between computer processors of various vendors will flourish. Processors and other computer hardware will be chosen for price performance relative to the specific needs of each user.

There are situations where the processor and operating system will influence, and perhaps control, the selection of GIS software. Organizations that, as a rule, have accepted a particular vendor as the supplier will limit software choices. In other instances, availability of existing processing resources, and the concomitant cost avoidance, will govern the choice of software.

Institutions must adapt to the technology. To do less will limit the benefits that are latent to GIS. Though it is possible to introduce GIS technology as a tool to replace what is now done manually or not at all, its integration into decision making and work flow will likely necessitate changes in the way an organization is structured and the way it works. Identifying both structural changes and procedural modifications is a step in getting started.

Structural changes may be threatening in any organization. Deal with it. When a system is implemented to increase the productivity or capability of an individual operating unit, structural changes are modest or nonexistent. Perhaps the drafting work force will require division into an automated group and manual drafting group, resulting in two lead draftspersons. On the other hand, the introduction of a GIS to support an entire agency; a company; or multiple government agencies, jurisdictions and companies will demand new agreements, formal and informal interactions, user committees, policy or management committees, cost allocation, joint budgeting, etc. New lines of communication and assigned responsibilities infer structural changes both subtle and specific.

And the way a task is accomplished can change. The availability of a single and consistent database eliminates steps previously taken in processing and validating zoning requests, work orders, information queries, etc. The physical movement of hard copy data is rendered obsolete, the storage and archival functions change or are

eliminated, and simple and complex procedures are modified. The extent an agency succeeds in altering procedures has a direct bearing on the integration of the technology and the realization of many of the technology's benefits.

SUMMARY

In summary, the identification of system function, database content, and institutional structures and procedures is an elemental step in getting started. The process is iterative, moving from the abstract, to a concept, to a preliminary design, to detailed design, and then specification.

SIGN UP OR SIGN OFF:
GAINING AND MAINTAINING SUPPORT FOR GIS

John C. Antenucci

President
PlanGraphics, Inc.
202 West Main Street, Suite 200
Frankfort, Kentucky 40601-1806
(502) 223-1501

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

This paper describes three techniques for gaining and maintaining support for a GIS, and the influences that can arise in gaining support for a GIS. There are three main approaches usually used to attain support: the technological approach, the political approach, and the educational approach. The technological approach includes a detailed definition of user's requirements and the preparation of a benefit/cost analysis, resulting in a clarified view of what technology offers an organization. The political approach within an organization is widely held as the most significant and effective way to insure the identification and active participation of a GIS sponsor. A sponsor, particularly one who has some senior management authority, can inspire the operational staff, temper their insecurities about dealing with new technology, and break down some of the barriers that might emerge when one attempts to more fully integrate the technology throughout the organization. The most successful systems are highly dependent upon the participation of key individuals more than on the available technology. The educational approach needs to occur at all levels of an organization. Senior management will want to know GIS costs, not only in terms of dollars; but in time, deviation or support of other priorities, and how it will impact external views of their management prowess.

INTRODUCTION

There are three techniques for gaining and maintaining support for GIS: 1) a technological approach, 2) a political approach, and 3) an educational approach. There also appear to be both internal and external influences that can be brought to bear in gaining support for a GIS. This paper will define each of these approaches and influences.

TECHNOLOGICAL APPROACH

The technological approach includes the traditional and detailed definition of particular user's requirements and the preparation of a benefit/cost analysis that, for the most part, is quantitative, but also takes into account intangible benefits. Much can be said about the details and technical utility of a benefit/cost analysis but, effectively, it produces a result that can also support the political approach described later. A key result of the technological approach is a clarified view of what the technology offers an organization. It addresses the high, and perhaps undue, level of interest in hardware and software and their distribution throughout an organization. More importantly, it defines, in rather precise terms, the database to be constructed and the applications which the database will serve.

It's quite clear that there is need for a technological analysis, regardless of where support for the system resides. In the specific context of gaining support, the technological approach is most often launched by the operational and sub-operational units in an attempt to obtain senior management support. The technological approach is typically used by those in the lower reaches of an organization who are attempting to push the idea from that level of the organization to more senior individuals.

POLITICAL APPROACH

The identification and active participation of a GIS sponsor is widely held as the most significant and effective political technique technology within an organization. Should that sponsor be in either management or senior management ranks, progress can be made at a much greater rate. In looking at it from two perspectives, the first being from that of senior management, it's not unreasonable for a senior manager to take the lead and become the champion of this type of automation. Sometimes those in the managerial level assume that the introduction of a new technology will be embraced by the operational units. That is not particularly the case. There are quite a few subtleties that complicate the implementation of such systems, even though there may be superficial support in the operational ranks.

By way of clarification, consider the instance where senior management has decided to pursue the implementation of GIS technology. For GIS to achieve its fullest potential, the technology must be embraced and integrated throughout the operational ranks. In many organizations, particularly large ones, the introduction of new technology and practices has a threatening aspect and is reluctantly received by the operational staff. A sponsor, particularly one who has some senior management authority, can inspire the operational staff, temper their insecurities about dealing with a new technology, and break down some of the barriers that might emerge when one attempts to more fully integrate the technology throughout the organization.

On the other hand, should the sponsor be at the mid-level or operational ranks, the challenge is all the greater. Lacking the clout of senior management, the individual must respond by using either the technological approach or the educational approach yet to be discussed. In this case, the operational individual may be more readily received by the operational ranks, but must win over the support of at least one individual from senior management who will serve as sponsor at that level in the organization. There are further complications where the sponsorship comes from an operational unit. Politics within the ranks of operational units are frequently well defined. Depending upon the personalities involved, there may be greater or lesser degrees of reluctance on the part of staff and managers at the operational level to embrace GIS.

The bottom line to the political approach to GIS implementation is that one or more sponsors are the most critical element of the process. As a result, the process is very much driven by personalities. Most successful systems are more highly dependent upon the participation of key individuals than on the available technology.

EDUCATIONAL APPROACH

Education needs to occur at all levels of an organization. The specific education needs vary by the level of the organization being addressed. One might define, perhaps somewhat arbitrarily, three levels. The first is senior management (i.e. agency heads, chief financial officers, chief executive officers, and chief operating officials). The second level embodies mid-level managers, unit managers, and those with responsibility for the functional operations of an organization. The third level involves the education needs of the work force (i.e. those who will be responsible for the day-to-day operation and use of the GIS technology).

Senior management will require an overview of what the technology is and what it can be expected to do. At the risk of over-simplifying, these individuals must be provided the bottom line view of how GIS will affect profit, efficiency of operation, and the ability to support a particular constituency. Moreover, they will want to know its cost, not only in terms of dollars; but in time, deviation or support of other priorities, and how it will impact external views of their management prowess.

At the mid-level, the educational effort must be directed to attain a higher level of understanding of the technology; the labor requirements needed to develop and sustain such a system, not only in terms of raw labor but in talent as well; and the financial impact. In many organizations, it is this level that must also be made to fully understand the significance of integrating the technology into daily practice. As an aside, the benefits to be accrued by the GIS technology are constrained if the resulting implementation goes no further than automating certain manual practices. Where the opportunity exists to consolidate transactions, eliminate redundancies, and expand upon functions that are not currently accomplishable in a manual mode, it is mid-level management who will be best positioned to orchestrate the change.

The third and operational level of the organization must be persuaded that this technology will extend their utility to the organization and perhaps marketability in general. If this is accomplished successfully, the initial reaction that the technology is a threat can be diminished or eliminated.

Education must address the applicability of the technology to day-to-day practices within the organization. In many instances, it is the mid and operational levels of the organization who are best situated to define how the technology can be used most effectively to eliminate redundancies, improve upon efficiencies in operation, and expand upon the organization's ability to undertake various tasks in an automated environment that it could not afford to do in a manual environment. One must insure that the labor force has a reasonable appreciation of the technology. The education must occur starting with concepts and go on to a detailed explanation of how other organizations are using it. This level of education cannot be limited to conceptual frameworks. For those individuals who are eventually going to have hands-on contact with the technology, a detailed understanding of a particular configuration or database's operational characteristics should be introduced at the earliest stages of investigation.

INTERNAL INFLUENCE

Obtaining internal support for the system is the traditional way of pursuing GIS technology. There are at least three operative models. The first is where senior management becomes aware of the technology, typically through contact with their peers, and impresses the idea upon the organization from the top down. As noted earlier, this is, in many cases, the quickest way of seeing results, but in many cases, the demands are met with some hesitancy or reluctance at the lower levels. Moreover, senior management's understanding of the technology might not be complete, and perhaps unrealistic, giving the agenda a spin that is unusual.

The second may be the internal support for GIS from mid-level management. In this case, the impetus must flow in two directions; one upward so as to convince senior management to proceed, and one downward encouraging and educating operational staff on the benefits, utility, and practicality to their day-to-day work activities.

The third approach might best be described by analogy as pushing the wet noodle. It occurs when technological staff have been persuaded that automation and adoption of GIS technology are essential to the long-term productivity of their operation. In this case, they must both educate and motivate mid-level and senior management.

EXTERNAL INFLUENCE

External influences are quite diverse and can be used creatively in gaining support for a system. As noted early, the peer group pressure syndrome is operative at all three levels of an organization, and has its greatest impact on senior management. Typically, the exposure comes from professional meetings or encounters with other senior management. An excellent illustration is that of SCADA systems within the electric utility organizations. By and far, the introduction of SCADA, or load analysis systems, was not accomplished as a result of rigorous benefit/cost analysis, but because a select group of utility executives were persuaded that this would lead to cost-effectiveness and higher profitabilities. The impetus was passed from one senior executive to another.

A significant external influence on any of the three levels is the wide range of conferences and professional meetings that describe, and to some extent exploit, the success stories of other organizations. Whether it is accomplished in senior management seminars or by way of large commercial or professional meetings, educational opportunities abound.

It is clear that an understanding of who is using the technology and the experiences, positive and negative, they are incurring will benefit an organization's efforts to develop GIS. There are other forms of education. One might reasonably argue that consulting organizations play an effective role in educating and developing an appropriate and realistic expectation of the technology. Again, this can be applied at any of the three levels, whether it's building a business management case for the most senior officials of an organization or whether it is providing the operational staff with a rigorous, technological appreciation and, perhaps, technological justification for GIS.

Moreover, there is an ever increasing number of user organizations who have achieved some success. Human nature being what it is, this organization can generally be persuaded to describe those successes and, quite frankly, some of the tribulations of developing the systems. As the user base expands and experience increases, existing users will have a very persuasive role in developing a ground swell of peer group pressure to embrace the technology. It wasn't too many years ago that word processing and word processing equipment were subjected to a great deal of examination prior to being purchased. Today, the purchase of that type of automation system is rather routine.

The same might also be said about the computer-aided mass appraisal systems. Even though they may not be the mainstay of an organization's efforts in appraisal, they are certainly becoming widely accepted as a tool - if only to validate the results of the more traditional practices of an organization. Acceptance is now a function of their routine use.

MAINTAINING SUPPORT

All of the same techniques can be used to maintain support. A few others can be added that will contribute to maintaining support once it has been established. We must recognize that there are various phases of system development, and maintenance of support will differ relative to the various phases of development. There are four different support phases. The first, or concept phase, occurs when someone within the organization at some level is mulling over the dimensions and direction that GIS might take within the organization. In the first phase,

one might include building the management case at the highest levels, and undertaking a requirements or feasibility study. The second phase can be considered the design phase. It is perhaps the most challenging. During the design phase, the organization begins to define details of hardware/software and database structure, and establish a priority for the various applications which will drive the design. The design phase typically leads into the third, or implementation phase, which includes the development of the databases, the procurement of computer hardware/software, the tailoring or design of application packages specifically for an organization, the acquisition and early tarining of key ataff to operate the system and maintain the databases, and to provide support to users in undertaking the various applications. The fourth phase is the operational phase.

Maintaining support during Phase I, the concept phase, is a moot question in the sense that this is the time when one is trying to gain support for the system. The other phases (i.e. design, implementation, and operation) require varying degrees of support that need to be maintained.

The design phase involves a relatively short period of time. If the organization has been supportive during the initial conceptual phase, support should at least continue through the design phase unless dramatic changes in direction are made during this phase. These directional changes might include increasing cost estimates by orders of magnitude and reducing anticipated benefits or reducing the utility of the system. Presuming that the original concept was well-founded, the design phase typically sees little demand placed on it from the point of view of maintaining support through that phase. The critical juncture occurs more frequently at the very end of the design phase, where organizations must deal with the harsh realities of time, dollars, labor, and the commitment to proceed. This will be a key focal point for maintaining support. One aspect of support for this phase might be a plan for early products and deliverables.

This facet also goes into the implementation phase. Classically, organizations typically presume that the system will be fully implemented before there are products. That is not the case. If the plan presented to management for the decision to proceed embodies early products and the implementation phase has within it various milestones in which products will be forthcoming, acceptance might be more easily assured.

In many GIS implementations, there are interim steps that must be taken to build databases and applications. With a bit of creativity, these exercises can produce products that have immediate utility even though they may be manually based or not a specific product of the GIS. As an example, in many cases when requirements analyses are done, a comprehensive review of existing data sources results. This survey or compendium can serve as an interim product until some of those resources can be brought together in an automated environment. Another illustration is where the development of base maps use aerial photography, and the photography can become a product. The survey control that goes into the photogrammetric mapping process can be made available as a product. Such products achieve both a visibility for the system and some attention to the immediate paybacks that are available.

Maintaining support during the operational phase is both easier and more difficult. Accomplishing the objectives and meeting the commitments to senior management and operational staff will be key to maintaining support. Failure to achieve the expectations laid out at an earlier stage will have the most dramatic effect on the sustenance of support for the GIS. Given a rigorous design of the system during the design stages, there is no technical reason why this catastrophe should occur.

SCANNING - AN ALTERNATIVE MEANS OF SPATIAL DATABASE CONSTRUCTION

David H. Armstrong

Canada Centre for Mapping Surveys
Mapping and Remote Sensing Sector
Energy, Mines and Resources
615 Booth St.
Ottawa, Ontario, K1A 0E9

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Data conversion has always represented the largest percentage of the effort required to put a geographic information system (GIS) in place. Manual techniques using digitizing tables to convert maps into digital form are used extensively, but are labour intensive and expensive when there are a large number of graphics. Scanning has been touted as the technology that can solve this problem. The act of 'scanning', however, represents only one phase of the complete analogue-to-digital conversion process. The immediate product of most scanning systems lacks the 'intelligence' necessary for it to be effectively used in today's GIS's. The Canada Centre for Mapping has employed scanning technology for several years as one alternative means of constructing the National Topographic Data Base. This paper discusses the steps necessary to convert scanned data into a readily usable GIS input and provides guidelines as to when scanning may prove to be a more effective digitizing alternative.

INTRODUCTION

The Topographical Mapping Division (TMD) of the Canada Centre for Mapping (CCM) is responsible for ensuring the availability of topographic information concerning the Canadian land mass to the standards of the National Topographic System (NTS). In addition to standard conventional map products at the scales of 1:50 000 and 1:250 000, the TMD is responsible for the acquisition, management and dissemination of topographic data in digital form. This is being achieved through the development of the National Topographic Data Base (NTDB).

The conversion of the information found on NTS maps to digital form plays an essential role in the construction of the NTDB. Scanning technology is being used to perform this conversion. The actual scanning function, however, is only one phase in the analogue-to-digital conversion process. It is used to perform the initial 'digitizing', yet, to generate a product suitable for use as a base framework for today's geographic information systems (GIS), much more work is involved. This paper discusses the vector data requirements for GIS's and offers a description of the phases involved in going from a graphic document to a finished data product. It is written primarily in the context of current NTDB technical capabilities, although various other methods and procedures are mentioned. A summary is offered regarding the basic guidelines to be considered when scanning is being investigated of as a spatial data base construction alternative.

EXISTING GRAPHICS AS SOURCES FOR GIS DEVELOPMENT

In GIS's, topographic data plays a vital role as a reference base for the analysis and management of other thematic information such as forestry, soils, land use, utilities, etc. In its own right, topographic data such as hydrography and transportation features are essential for network applications. In addition, contours can assist in applications that require a three dimensional representation of the terrain.

The purpose topographic data is to serve ultimately determines a range of required characteristics such as: positional accuracy, coordinate density, structure, feature coding/attribute complexity, dimensionality, validity date, and content. The appropriate source, data capture technique, and post-processing methods have to be chosen that satisfy these characteristics.

There are numerous sources from which to capture digital representations of topography. Data can be encoded from photographic and satellite imagery. It can be captured directly in digital form using airborne and satellite sensors. On the ground, feature positions can be collected using digital field survey techniques.

Perhaps the most popular method, however, has been the digital encoding of features from existing graphic documents - or maps. Many mapping and resource agencies have recognized that they have a valuable store of information on their conventional maps and in order to expedite the completion of digital topographic base layers, have opted to embark on significant map digitizing programs. Although the digitizing of existing maps may not offer the most accurate or current information, agencies have recognized that relaxing these two factors is necessary in order to complete large geographic coverages at medium scales (i.e. 1:50 000) within a reasonable time frame. For example, almost 13 000 - 1:50 000 maps are required to cover Canada and each map averages 4 to 5 overlays to be digitized.

From an accuracy perspective, data derived from maps is inherently 'cartographic' in nature and, therefore, is subject to positional movements incurred during the map production process. In contrast, more precise data capture methods, such as direct stereocompilation, result in data that is 'positional' in nature, not having been affected by cartographic generalization or symbolization. Naturally, the validity date of digitized feature representations can only be as current as the information contained on the map and, hence, a sacrifice in this regard is sometimes necessary. Data captured directly from imagery is normally more up-to-date.

The choice to digitize existing maps has been, and continues to be, a popular route. Mapping agencies responsible for the construction of large spatial databases, such as the Canada Centre for Mapping (CCM), United States Geological Survey (USGS), and Defence Mapping Agency (DMA) have chosen scanning technology to help them fulfill their broad mandates.

DATA REQUIREMENTS

To simply 'digitize' existing graphics is not sufficient for today's GIS's. In fact, the digitizing process is only one function in the overall graphic-to-digital conversion process, and it does not constitute the most complex or time consuming one.

The conversion process consists of a transformation of spatial information form through a number of stages summarized below:

Stage	Description
1. Graphic Document	Either a paper map or reproduction separates in the form of positives or negatives.
2. Digitizing Source Document	The document to be scanned. Normally a modified version of the original graphic that has been altered to enhance data conversion.
3. Raster Data	A matrix or grid of pixels that depict features by carrying information pertaining to: the presence or absence of an image at their location, a grey scale value pertaining to the detected light intensity, or a value indicating color calibration.
4. Raw Vector Data	Collections of coordinate strings and points.
5. Coded Vector Data	Collections of coordinate strings and points that are assigned identifying feature codes.
6. Structured Vector Data	Data suitable for GIS input. Collections of coordinate strings, points, and area labels that are feature coded and spatially ' clean'.

The stage at which the transformation is considered complete depends upon the role that the data is to serve. For GIS applications, structured data, or stage #6, is a necessity. In fact, the generation of structured, intelligent data that is readily usable is "the most important and complex task upon which the usefulness of a GIS depends" [Burrough, 1986] and that "a clear consensus is emerging" [Woodsford, 1986] that map data in structured form is a must.

To act simply as a digital background for visual examination and interpretation on a graphics terminal, only a collection of coordinate strings combined with the proper assignment of color and/or symbolization, stages #3 or 4, is required. This may be achieved in either a raster or vector environment, or a combination thereof.

To allow selective plotting and computer-assisted map production, the coordinate strings and points must be feature coded or separated into layers or themes - stage #5.

To effectively supply a GIS with data for manipulation and analysis requires structured data - stage #6. Structured data has many different meanings to different people, although, it is generally understood that this form of data preserves the fundamental spatial relationships among features that are normally recognized when visually examining a map. Some of these spatial relationships are connectivity, adjacency, and containment and they can be realized either implicitly or explicitly in the digital environment.

Explicitly, spatial relationships are preserved by adopting the principles of topology and using a data model that is basic to all vector-based GIS's. This model breaks topographic reality down into three basic data types, or objects: 1) points, 2) lines, and 3) polygons (or areas) [Dangermond, 1988]. In this sense, all features can be represented by zero, one, or two dimensional geometric objects, or a combination of them. Topology is concerned with the maintenance of the spatial relationships among these objects, independent of the geometry

that describes them, i.e. topology is not concerned with the sizes or shapes of objects. Each object is assigned an unique identifying number and relationships are expressed 'explicitly' using pointers or lists that indicate for example: at what points a line begins and ends, what areas are on the left and right sides of a line, what lines connect at a point, what lines bound an area, what areas are inside other areas ... the list can go on. An example of a digital cartographic product that offers explicit structure is the USGS Digital Line Graph [USGS, 1986].

In data that is implicitly structured, spatial relationships among objects are not expressed using any specific pointers or lists. Instead, they are maintained solely by virtue of the location of the coordinates depicting their position with respect to one other. This lack of explicit structure has often resulted in this type of data being termed 'spaghetti' data. However, data that offers correct implicit relationships can be considered 'spatially clean' if lines form a mathematically connected network and they precisely close when they bound area features that contain an identifying interior label or centroid. This type of data must be void of spatial inconsistencies such as: linear overshoots, undershoots, and polygon misclosures. In this form data can be readily loaded into a GIS for subsequent use and it is this type of product that a digitally converted graphic should provide.

There is often some question whether explicit topology should be part of a digital topographic product. This depends greatly upon the complexity and detail with which the digital product is to model reality. For instance to provide area containment relationships or the recognition of compound objects, some forms of explicit pointers are required. However, the guarantee of basic connectivity and adjacency relationships among objects can be achieved implicitly. To guarantee these spatial relationships though, the data must be passed through topological network and polygon structuring software for quality control purposes. The topological relationships generated at that time can be kept and passed on in an exchange format if there is a need to accommodate them (e.g. [CCSM, 1989]), but it is the experience of the CCM that although topological structuring ensures a spatially clean file, the explicit pointers are generally ignored upon input to a user GIS [Statistics Canada, 1987]. These systems generate their own topology as a matter of course upon input. Perhaps when the transfer and sharing of structured topographic data becomes more commonplace, and data volumes increase, consideration will have to be given to the transfer of basic, explicit topological pointers that will allow pre-processing to be bypassed, or at least minimized at the user end. Of course a major task would have to be initially performed to develop specifications that define what 'basic', explicit topological relationships are, and how they are to be encoded to satisfy the majority of the user community.

Some early digital topographic database construction efforts focused on the collection of 'feature coded' (or stage #5) data. This data fully satisfied map production needs perceived at the time, but to meet the requirements of GIS's it must be enhanced to conform to the structural characteristics described above. Existing NTDB data falls into this category and new specifications for the digital topographic product have been recently re-designed. This is not to say that most GIS's do not have pre-processing software and interactive capabilities to refine and structure data prior to input. This process, however, can be very laborious and time-consuming depending on the amount and nature of the spatial inconsistencies that are found.

THE GRAPHIC-TO-DIGITAL CONVERSION PROCESS

Figure 1 shows that there are several path options to achieve structured data. Depending on the method of digitizing chosen, and the characteristics of the graphic to be digitized, some of the stages listed in the previous section may or may not be encountered.

The two basic approaches to digitizing involve either raster or vector data capture technology. Vector methods only will be mentioned here. For more information refer to Cameron (1984) and Marble (1984).

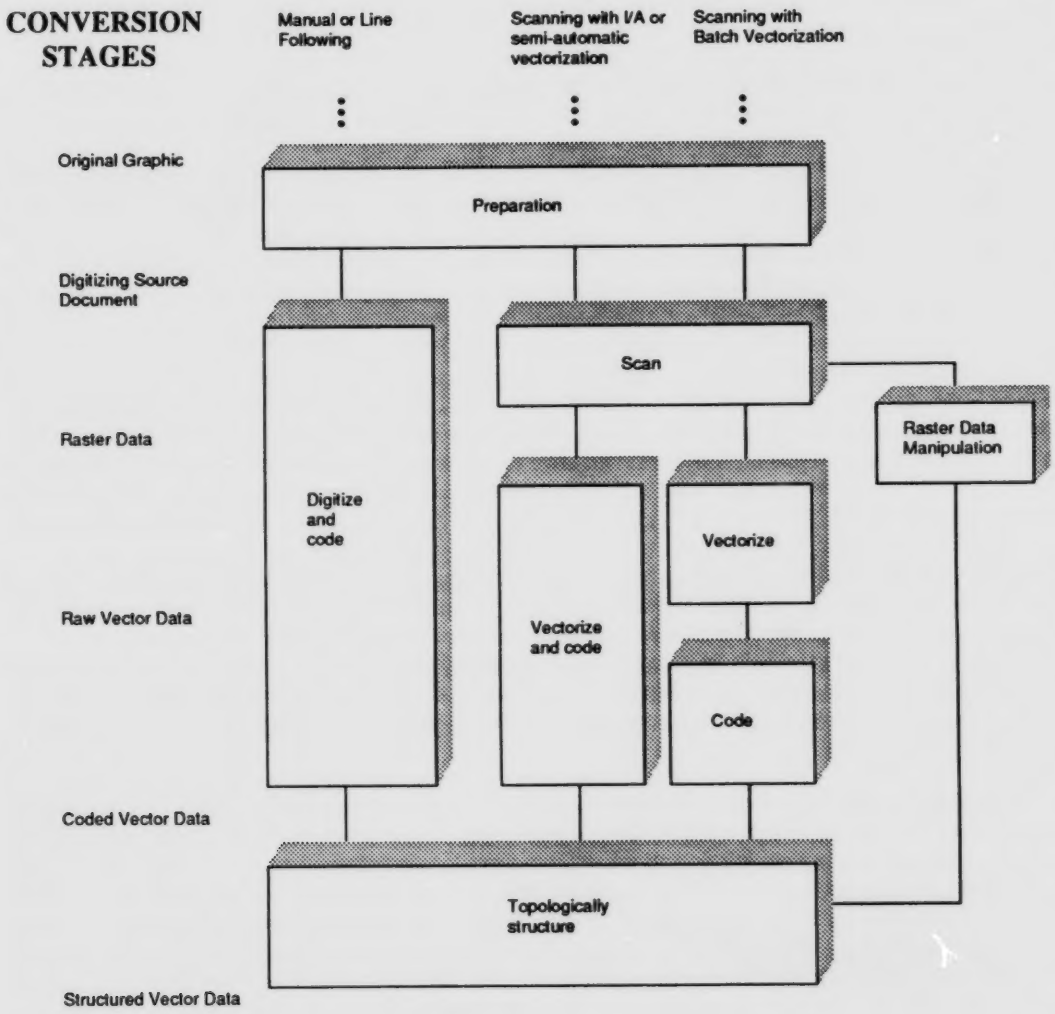


Figure 1. Data Conversion Stages

Vector Methods

Vector methods include those technologies that directly capture data in vector form, such as manual digitizing tables and scanning devices that are based upon line following principles. Because of the lower cost and complexity "the overwhelming majority of cartographic data entry is now done by manual digitizing" [Dangermond, 1988].

One of the key characteristics of the manual and line following approaches is that they bypass the raster data and raw vector stages. Digitizing is either under full-time or semi-automatic operator control and codes can be assigned to identify features as digitizing progresses.

Raster Methods

Raster methods utilize scanning devices that capture the graphic image as a matrix of pixels that require a subsequent conversion to vector form.

The steps necessary to achieve a structured data input for a GIS are: 1) Preparation, 2) Raster Scanning, 3) Vectorizing and Feature Coding, and 4) Topological Structuring. Each of these steps is described below.

Preparation

The preparation of graphic documents for scanning is perhaps the most important step of all because it facilitates all subsequent data conversion steps.

Although any graphic document can be scanned, most map series (such as the NTS) were not produced with scanning in mind.[1] There are, however, characteristics of the map production process that do facilitate mass digitizing by scanning. For instance, with polychrome map production, features that generally belong to a common feature class are found on a separation negative corresponding to a particular color, e.g. hydrography on blue, hypsography on brown, etc. What this offers is the beginning of a logical breakdown of features into common classes or groups.

The way that topographic features are depicted on the conventional map can, however, cause problems in their conversion to the digital environment. From a conversion perspective there is a natural conflict between the cartographic and digital representation of some topographic features. Cartographically the concern is to portray information in the most aesthetically pleasing manner. In the digital environment, visually pleasing hard copy output is also of concern, but it is also paramount that topographic reality is effectively modeled and structured for subsequent computer analysis and management. The problem with existing maps is the extensive use of cartographic symbolization.

The preparation function is a manual operation required to reduce or modify previously symbolized features so they can be easily captured as either points, lines or area labels. All three of these objects can be found in a symbolized manner. For example, it is desired that the coordinate location of points such as schools, churches and campsites are captured and not the coordinate of the vectorized symbol that represents them. Linear symbolization can effect the continuity of features such as power transmission lines and railroads that are shown using dashed or patterned lines. Perhaps the most problematic features are symbolized area features - for example, marshes and sand areas. The spatial location of the boundary of the area is required with an identifying interior label, but they are represented by an unbounded pattern (e.g. dots for sand or marsh symbols).

During preparation, point symbols may be removed from the base if they are combined with a large number of linear features, and captured later by manual digitizing. Symbolized lines may be manually prepared to join large gaps between dashes. The boundary of patterned areas can be manually drawn at preparation time and the pattern removed. All of this is an effort to capture spatially clean data.

---

[1] *With the exception of the USGS 1:100 000 series [Guptill, 1983]*

The amount of preparation depends greatly upon the symbolization characteristics of the features found on the map and the capabilities of the digitizing system to transform the symbolization into a proper spatial description. Experience with the NTS digitizing program reveals that the time required for preparation varies considerably because of ever changing map content. But on average, 3 to 4 days are necessary to prepare a complete map sheet consisting of 4 to 5 overlays. It is a task that requires a great deal of expert judgement and is essential in optimizing digitizing throughput.

Raster Scanning

Raster scanning converts analogue graphics (found on the digitizing source document - stage #2) into a digital matrix of pixels (or raster image - stage #3) by sensing transmitted or reflected light intensities using photo-sensors passed over the surface of the document or by using solid state matrix camera technology. To accommodate a complete map, typically up to 100 cm by 100 cm, a large format, flatbed or drum design is required. Map portions can be scanned using smaller formats or matrix cameras, however, it must be possible to accurately mosaic the portions at a later time to generate a complete image.

The scanning phase is the truly 'automated' portion of the conversion process. Although with large systems that offer calibration, thresholding, variable resolution, etc. to enhance the capture of the raster image, a technically skilled staff is required to initiate the scanning process. One of these tasks is the choice of scan resolution required to retain the positional accuracy of linear features. It has been noted that the resolution should be approximately one half the width of the smallest line found on the source document - the Nyquist Frequency [Skiles, 1988]. The minimum line width found on NTS reproduction material is 0.004" or 100 mm. The bulk of the scanning done by the CCM is at a resolution of 50 mm. A 25 mm resolution can be used in special circumstances.

Once parameters are set, the actual scan time is dependent upon the resolution chosen. At 50 mm and 25 mm the scan times are approximately 1/2 and 2 hours respectively. Since an average of 5 overlays are scanned per map, the total scan time is approximately 3 hours.

Vectorizing and Feature Coding

Vectorizing is the process of converting features represented as raster images to vector, or coordinate string form. Feature coding refers to the assignment of information or intelligence to the vector data. These two operations represent the bulk of the effort in the digital conversion process [Callahan, 1983].

Vectorizing and feature coding can be performed simultaneously or in tandem, as shown in Figure 1. One method performs vectorization and feature coding in an interactive (IA) and/or semi-automated (SA) mode; the other performs each function separately - vectorization as a single-pass batch process followed by IA and/or batch feature coding.

IA and SA vectorization is performed at a graphics terminal and requires full-time operator supervision. Its advantage is that simultaneous feature coding and editing can be done as work progresses. The IA approach emulates the manual digitizing process in a computer graphics environment where the operator places vectors directly on top of the displayed raster image using interactive tools. The SA approach allows individually selected raster images to be automatically tracked and vectorized in a local mode [Shea, 1987]. Both IA and SA approaches bypass the raw vector, or stage #4 of the topographic conversion process because intelligence, in the form of feature codes and other attributes can be assigned as features are vectorized. During IA or SA vectorization, editing can also be performed to remove unwanted information resulting from the scanning of the source document. Examples are noise and rasterized patterns or symbols not dealt with at the preparation stage. Editing of linear overshoots and undershoots can also be performed at this time.

The batch processing approach performs a complete vectorization of a raster image resulting in a raw vector file. This is the approach used by the CCM. Similar to IA editing, some automatic corrections can be performed during batch vectorization or as a post-process. Some examples are the removal of noise, removal of ticks, elimination of linear bridging, and line smoothing. The remainder of the corrections must be performed interactively.

The next task is to assign feature codes. Two routes are possible: 1) Using batch software, or 2) Using IA feature coding. These two approaches are often used in combination.

To eliminate the dependence on the operator and reduce the time requirements spent on interactive systems, it is desirable to utilize automatic (batch) software processes to interpret and code features based on characteristics retained in both raster and vector data. At the CCM in-house software has been developed that significantly reduces interactive edit and coding times [Huppé et al, 1986]. The software uses a combination of parameters such as line thickness, line style, line length, and topological node order to automatically distinguish single line watercourses and water bodies, to code different classes of roads, and to extract rapids and falls. The combined time to perform batch vectorization, feature coding, editing, and coordinate transformation is approximately 3 hours of CPU time per overlay or 12 to 15 hours per mapsheet.

Since automatic coding and editing cannot be 100% effective, IA methods must be used as a follow-up to code features and correct any mistakes made by the automatic process. IA coding requires that each raw vector feature be individually identified on the graphics screen using a pointing device, such as a cursor, and assigned an appropriate code chosen from a menu or key in. Some methods are available to interactively group features of a common type for multiple feature code assignment. Other methods successively assign codes and elevations in multiple fashion by interactively placing a line across a series of increasing or decreasing contours and keying in a starting elevation and contour interval [Wong, 1984]. The average time required for IA follow-up varies greatly but the average is approximately 4 days per map.

Other systems are capable of detecting color to perform similar operations [Callahan, 1983]. In the event that automatic feature detection cannot be performed, all of the data for a particular scan is generally coded in bulk according to the most predominant feature found on the graphic [Callahan, 1983].

As shown in Figure 1, the detection of features can also be performed using raster data manipulation. This is predominantly useful for point features that can be recognized using pattern recognition techniques such as template matching or statistical methodologies to analyze raster data patterns [Skiles, 1988].

Topological Structuring

Topological structuring is the final stage prior to completion of a structured data set. It is an essential quality control phase that ensures the internal consistency and structure of the data that has been digitized, feature coded, and edited. It can also perform some automatic editing functions when spatial inconsistencies are found that were not taken care of during earlier stages of conversion.

Structuring normally consists of the software construction of networks and polygons - processes that are integral parts of GIS's. During this phase, checks for the following may be made: duplicate features, linear overshoots and undershoots, unclosed polygons, polygons with missing interior labels, edge ties, feature continuity, 'hanging' linear features (for example, in a hydrographic network).

SCANNING FOR NTDB CONSTRUCTION

The NTDB is presently comprised of scale-specific (1:50 000 and 1:250 000) data, existing as a collection of archived files organized on the basis of the NTS. The data represents features from categories such as: hydrography, hypsography, transportation, utilities, buildings, vegetation, structures, etc.

Data has been collected in-house since the late 1970's using direct digital stereocompilation techniques for the 1:50 000 component. There is also an active contract program that began in 1983 with private industry contributing to this effort.

Since 1984 , scanning technology has been used in combination with manual digitizing to capture features from 1:250 000 reproduction material. The encoding of this information is scheduled for completion at the feature coded, vector level in latter 1989.

A cooperative digitizing effort with the Yukon Land Use Planning Directorate was launched in December 1988 to begin the first production scan digitizing of 1:50 000 NTS reproduction material. The work is being produced using scanning technology on a contract basis to a private sector that has revealed a very active data conversion service capability. This effort will result in structured, spatially clean data. The production system in place at the CCM is known as CARDAPS (Cartographic Data Processing System). It consists of a combination of SYSSCAN and Intergraph computer mapping and graphics systems.

Scanning is performed on a Kongsberg flatbed scanner. Post-processing (batch raster-vector conversion, data editing and feature coding) is performed using a combination of SYSSCAN and in-house software. Interactive editing and coding are performed on the Intergraph system.

Scanning will continue to play an increasingly important role in the acceleration of NTDB development with the acquisition and implementation of an additional scanning system at the Canada Centre for Geomatics; a sister organization of the CCM located in Sherbrooke, Québec.

The digital conversion of existing graphics plays a vital role in the overall development of the NTDB. To fulfill an objective of national digital coverage by the end of the century, an approach is being followed in which approximately 90% of the land mass will be covered by data generated by scan digitizing of existing NTS maps. This 90% region is generally considered to be remote, wilderness, or of low cultural density where accuracy and validity date constraints will be minimal because of the lack of man-made features and the reduced influence of cartographic generalization. The remaining 10% represents areas of high economic growth, population, and man-made construction activity. To overcome the accuracy and validity date constraints resulting from the digitizing of NTS maps, this portion will be covered using digital stereocompilation methods.

SUMMARY - GUIDELINES FOR USING SCANNING TECHNOLOGY

The choice of scanning technology as a data conversion route is not suitable for everyone interested in building a GIS framework from existing graphics. Assuming that a 'GIS ready' product as described in this paper is required, three main factors must be considered: 1) The number of documents to be digitized, 2) The nature and quality of the documents to be digitized, and 3) The accuracy requirements of the encoded data.

Without a large number of maps resulting in an ongoing digitizing program it is difficult to cost- justify the purchase of a raster scanning and editing system. There is an emerging trend today, however, that can alleviate such a large capital investment for smaller scale efforts. It is an active scan digitizing service industry that can perform everything from preparation to topological structuring.

National programs, encompassing thousands, or tens of thousands of maps, each composed of multiple overlays, do not suffer from a lack of documents. Numbers alone, however, are not a strong enough argument to adopt scanning. The nature of the original document and the required accuracy of the encoded data with respect to the original must be considered.

For instance, many cities implementing a GIS may have a significant number of documents containing, for example, hydrography, roads, utilities, property ownership, etc. They have, however, opted for manual digitizing primarily because a vast mix of unrelated features are found on a single document and, therefore, cannot be intelligently coded using automated techniques. This was a key factor for the city of Birmingham, Alabama in choosing manual digitizing over scanning [Hanson, 1988].

Scanning is best when the line work on the documents is of high quality, medium to high density, and pre-organized into feature layers to assist in automatic feature coding. Polychrome map products give data conversion a head start by being composed of map reproduction separates that offer a logical breakdown of features.

Scanning is also more beneficial if the documents contain little cartographic symbology. Otherwise, preparation of the documents will be necessary to assist in the capture of data that can be easily structured.

From an accuracy perspective, data captured by scanning is attractive because it is not subject to the limitations of an operator who tries to digitize the exact centre line description of a feature.

Scanning is not a 'one-shot' digitizing effort. When properly structured data is required, it is just one stage in an overall conversion process. Depending on the characteristics of the documents involved, it can contribute significantly to the accelerated development of a digital spatial framework for a GIS.

REFERENCES

Burrough, P.A. 1986. **Principles of Geographic Information Systems for Land and Resources Assessment.** Oxford University Press, New York, NY.

Callahan, G.M. 1983. "Digital Cartographic Data Production Using Raster Scanning Techniques", **Proceedings of the Six International Symposium on Automated Cartography.** Ottawa, Ontario, October, 1983, v.1.

Cameron, E.A. 1984. "Manual Digitizing Systems", **Basic Reading in Geographic Information Systems.** SPAD Systems Ltd., Williamsville, NY, 1984.

CCSM. 1989. **Standard EDP File Exchange Format for Digital Topographic Data. v.1.2.** National Standards for the Exchange of Digital Topographic Data, v.I, Part III, EMR, January, 1989.

Dangermond, J. 1988. "A Review of Digital Data Commonly Available and Some of the Practical Problems of Entering Them in a GIS", **Proceedings of Technical Sessions of the 1988 Annual Convention of the ACSM and ASPRS.** v.5, St. Louis, MO. March, 1988.

Guptill, S.C. 1983. "An Intermediate-scale Digital Cartographic Data Base for National Needs", **Proceedings of the Six International Symposium on Automated Cartography.** Ottawa, Ontario. October, 1983, v.1.

Hanson, R.J. 1988. "Conversion of Municipality Records for a Geographic Information System, Considerations and Techniques", **Proceedings of GIS/LIS'88.** San Antonio, TX. November, 1988, v.1.

Huppé, P. and J.L. Moisan . 1986. **Bypass Project Functional Specification.** Software Support, Technology and Standards Group, Topographical Mapping Division, CCM, EMR, Ottawa. April, 1986.

Marble, D.F. , J.P. Lauzon and M. McGranaghan. 1984. "Development of a Conceptual Model of the Manual Digitizing Process", **Basic Reading in Geographic Information Systems.** SPAD Systems Ltd. Williamsville, NY. 1984.

Mounsey, H. and R. Tomlinson. 1988. **Building Databases for Global Science.** Taylor and Francis Ltd. London, U.K.

Shea, K.S. 1987. "Cartographic Data Entry Through Automatic Feature Tracking", **Proceedings of the Eight International Symposiums on Computer-Assisted Cartography.** Baltimore. MD. March, 1987.

Skiles, J.M. 1988. "Tools and Techniques Used in Scan Conversion of Geographic and Facilities Data", **Proceedings of GIS/LIS'88.** SanAntonio. TX. November, 1988, v.1.

Statistics Canada . 1988. **Evaluation of EMR Topographic Survey 1:250 000 Test Data Set for Sheet 21I (Moncton).** Ottawa. March, 1988.

USGS. 1986. **Digital Line Graphs from 1:24 000-Scale Maps.** Data Users Guide. Department of the Interior, USGS, Reston. 1986.

Wong, C.K. 1984. "Digital Mapping and the Reality of Generating and Using Three Dimensional Topographic Data Bases", **Proceedings of ISPRS Congress Commission IV/8.** Rio de Janeiro. Brazil. June, 1984.

Woodsford, P.A. 1986. "Cartographic Digitizing - Technical Trends and Economic Factors", **Proceedings of Auto-Carto London.** ICA. London, U.K. v.2.

TERRAIN RESOURCE INFORMATION MANAGEMENT (TRIM)

A STANDARDIZED GEO-REFERENCING DATABASE FOR THE PROVINCE OF BRITISH COLUMBIA

Roger Balser, P.Eng.

Manager, Programs
Ministry of Crown Lands
Surveys and Resource Mapping Branch
Contracts and Development
Parliament Buildings
Victoria, B.C.

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

The Terrain Resource Information Management (TRIM) program will provide a digital terrain data model of the entire province of British Columbia which covers some 950 000 square kilometres. The high quality topographic data produced by TRIM will facilitate the production of resource information systems within the British Columbia government as well as within the resource industry. This will further set the stage for the development and utilization of a high technology GIS industry in the Province of British Columbia. This paper will give details on the TRIM program including deliverables, production schedules, availability of data and costs.

1.0 INTRODUCTION

TRIM is an acronym for the Terrain Resource Information Management project. This is a major 1:20 000 scale digital mapping project being jointly undertaken by the British Columbia Ministry of Crown Lands and the Digital Mapping Group Limited (DMG), a consortium of nine British Columbia private sector surveying and mapping companies. The program was initiated through an unsolicited proposal procedure from the DMG to the Provincial Government. It was recognized by the government that there was a need for this type of program in British Columbia in order that: industry develop state-of-the-art technology; a high technology work market evolve in British Columbia; and that the Government provide the digital topographic data base necessary for the proper long range management of its natural resources through the emerging technology of Geographic Information Systems (GIS).

The Province of British Columbia covers an area of some 950 000 square kilometres and it would seem that most of those are mountainous. British Columbia represents some of the most difficult terrain in Canada, if not the world, in which to perform the tasks of surveying and mapping. The task faced by the TRIM program is to provide aerial photography, survey ground control, aerial triangulation, cadastral compilation and digital topographic data files for some 7 000 map sheets to support the raw data requirements to drive the GIS development.

2.0 GEOGRAPHIC INFORMATION SYSTEMS

A Geographic Information System (GIS) is a set of tools designed to support the planning and decision making functions of an organization; it is based on information processing technology for inputting, storing, manipulating, analyzing, and displaying spatial data. The technology for resource management through GIS is a reality; however, the realization of the effectiveness of this technology can be hindered by the absence of fundamental requirements, one of the major of which is structured, digital base map reference files.

Over 40% of the British Columbia Gross Domestic product is derived from forestry, mining, petroleum, hydro-electricity, fishing and agriculture. The proper management of these natural resources requires the ability to evaluate the global effect of a management decision by being able to integrate the business data of each sector. A decision cannot be made in isolation as there are cross boundary effects. The integration of the resource information systems of the Ministries of Energy, Mines and Petroleum Resources, Environment, Crown Lands, and Forests, as well as Highways may be realized through the common geographic reference data base to be provided by the TRIM program.

3.0 DATA, DATA STRUCTURE AND APPLICATIONS

The topic that I would like to address is that of the actual magnitude of this task and the actual deliverable data that are associated with the TRIM program.

3.1 AERIAL PHOTOGRAPHY

Aerial photography required the acquisition of some 60 000 line kilometres over a period of three years. There are areas in the northwest of the Province that have a photo window of approximately one day per year; any mariner will tell you what the fog conditions in the Queen Charlotte Islands region is like.

The aerial photography was flown using a Lear jet equipped with an RC-8 camera using a six inch focal length. The scale of the photography is 1:60 000 and 1:70 000. TRIM has met the aerial photography objective at a cost of less than $25 dollars per line kilometre.

3.2 GROUND CONTROL AND CADASTRAL

The ground control portion of TRIM planned for the coverage of the Province in a three year program. In reality, the ground control will be provided at a rate to insure that there is sufficent data available for aerial triangulation. Field programs were run in 1986, 1987 and 1988. The remaining control requirements have been planned and could be completed in one field season, however, there is no plan for a field survey season in 1989.

The ground control is being placed to meet the requirements of the aerial triangulation of large blocks of models. As well as the ground control, there is also the requirement of locating sufficient cadastral ties in order that the cadastral fabric be compiled and fitted through coordinate geometry calculations. This will place the cadastre on the same geographic reference framework as the planimetric digital base so that the digital base map and the cadastral overlay will tie together. The link between the cadastral points and their geographic location will be made at the time of aerial triangulation by transfering the cadastral target position identification from the ident photo to the small scale mapping photography. The cadastral point is given an unique identification code and then cross-referenced to the UTM adjusted coordinates output from the aerial triangulation results. These are the first steps being taken toward a coordinate-related cadastre in British Columbia.

The ground control positions are being established by Global Positioning Systems (GPS) technology. This technology has proven itself very cost-effective when planned and utilized efficiently, particularly in British Columbia where the mountains and weather render surveying a precarious adventure at best. One of the limitations to this technology meeting its predicted accuracy, is the accuracy of the GEOID model that is used. As you can imagine, in British Columbia with its topography, this is a real concern. The Branch, in conjunction with the Federal Government, has cost-shared in a contract to the University of Calgary in the development of a GEOID model for B.C.

This GEOID model will be available to all users of satellite data in the Province.

The reference ellipsoid for the TRIM program is the World Geodetic System 1984 (WGS84) and the datum will be the North American Datum 1983 (NAD83).

There is a significant amount of control, both horizontal and vertical, in the Province; however, the accuracy, identification and location may not always be suitable for the aerial triangulation process. To date, some 60% of the Province has been survey-controlled.

3.3 AERIAL TRIANGULATION

The aerial triangulation is planned to take advantage of the computer and program capabilities of large block adjustments. This tends to minimize the amount of horizontal ground control needed and at the same time renders the procedures of the associated tasks (coding, pugging, mensuration) to a production line technique. The objective is to adjust blocks of approximately 2 000 models or 600 BCGS map sheets. By March 31st, approximately 40% of the Province will have been aerial triangulated.

3.4 DIGITAL DATA CAPTURE

There are approximately 7 000 map sheets at a scale of 1:20 000 needed to cover the Province. Of these, approximately 1 400 in the Lower Mainland and Vancouver Island have been produced by the Branch in a graphic or spaghetti file format. The limitations of this data are recognized and these map sheets will either be updated to the new specifications or recompiled to meet the TRIM specifications. Evaluations have shown that recompilation is more cost-effective. The Ministry of Crown Lands must set the priority and objectives for the TRIM program in order that clients can be given a long-term production plan for the direction of TRIM.

TRIM digital data is based on a set of specifications that we feel will become the yardstick by which other digital data will be measured. I will explain why that is. In British Columbia, the economy is driven primarily by the resource sector. These resources are spread across the Province and therefore maps are a very common tool utilized by the associated industries. In order that these companies be able to carry out their activities, it has often been necessary for them to produce their own maps. These maps, for the most part, were being produced by the companies that now form the Digital Mapping Group. We, therefore, have the opportunity of dealing with a larger user group who are very cognizant with not only the value of good map data but in many cases with what is required to produce maps and what the costs involved are. Another factor is that some of the companies involved in the mapping are also major users of the data. This had the effect of placing the producers and the users of the data around the same table when the specifications were being finalized.

Some of these companies were already familiar with Geographic Information System technology and were either using it or investigating systems suitable for their GIS applications. This being the case, it was seen that our data must contain the structure necessary for easy transportability in a GIS-come-computer sense and that any transfer

formats must be stable and controlled by the Ministry. The alternative to this was for the Ministry to 'pick' a system and essentially tell our clients that was what we would support. What we see emerging in the GIS market place are systems that span a very wide range of costs and sophistication in their applications. It would be totally unacceptable for a Government to produce data that restricted easy accessibility to only a narrow segment of the market; there are big users and there are little, however, they are all users. In the past what has prevented the little user from becoming a big user was the lack of availability and cost of the digital map base data. TRIM will, and is, changing that in British Columbia.

A geographic information system is composed essentially of two sub-elements: an electronic base map with user data overlays and an associated attribute data base. Both of these can and do serve useful purposes; however, neither reaches its full potential until the link is made between the two. When this occurs, one can truly speak of a GIS. The level of GIS application depends on the structure and sophistication of both the data in the electronic map and the data base. The higher level GIS's have as a premise that the graphic data is fully structured. Most of these systems have a health checking routine that 'flags problems' with the data. If the input data is not 'clean', this can result in an unacceptable amount of interactive editing and/or the use of batch programs in attempts to overcome the problems. The inability of a user to easily access and use the data will soon lead to frustration and negative feedback.

The objective of TRIM was to set up the specifications so that they would be useful to the most primitive of GIS systems. The data would also be readily useable in strict application types of development where it would be necessary for map features to 'stand alone'. In order to meet this objective, each map feature was given a feature code that conformed to the national Canadian Council of Surveying and Mapping (CCSM) standards. In addition, all faces of common features were mathematically duplicated so that any given feature would be contiguous and self-contained.

The data is created to adhere to certain rules of structure:

Right Hand Rule
- All polygon features will be digitized such that the features lies to the right of the direction of digitizing.

Downstream Rule
- All rivers and streams will be digitized in a downstream direction.

Continuity Rule
- Features will not be broken for other features, rivers will be digitized continuously across roads, through dams, etc

Polygon Rule
- All area features will be explicitly closed polygonal areas, with Right Hand and Downstream Rules applied. Exact duplication of data will be done to close all polygonal features. These duplicate line segments will be given their appropriate feature code; however, they will be treated as construction lines in the file.

Connectivity and Network Rule
- All lines of like and unlike feature groups which intersect or close on themselves will do so at numerically and mathematically exact coordinated junction points or nodes. These nodes divide continuous features into discrete elements which begin and end at nodes.

3.5 DIGITAL ELEVATION MODEL

One of the products that has generated considerable interest is the Digital Elevation Model (DEM). This will be a separate 3-dimensional file containing mass points collected either in a random mode or a grid mode, supplementary vertical data extracted from the planimetric file, as well as break lines and ridges to aid in the surface interpolation. The mass points will fit a grid spacing of 50 metres in steep terrain and 75 metres in less complex terrain when captured in a true grid method. When a random point selection is used, the approximate grid spacing will be 75 metres in steep terrain and 100 metres in flatter, less complex terrain. This data will be supplemented by breaklines, ridgelines and planimetric data of a sufficient vertical accuracy to be included in the DEM.

The standard deviation of the DEM points will be 5 metres. This data will be of a sufficient density and accuracy to support the interpolation of a 25 metre grid. This grid sizing is significant in that it will conform to the pixel dimensions for utilization in satellite remote sensing applications.

3.6 POSITIONAL DATA AND REPRESENTATIONAL DATA

The Ministry will take delivery of two map products from the Digital Mapping Group. They will be the Positional file and the Representational file.

The positional data is essentially the raw data as it is captured from the photographs. The data will be cleaned and edited so that it meets the specifications; however, there is no cartographic displacement of any of the features. The positional data will consist of the planimetric detail with the associated generic text, the digital elevation model and the raw contour file. This data will be supplied to the Branch in the MOEP format. This is a simple ASCII file that serves as a file transfer format among the Ministry and the companies of DMG.

The Representational data will be the result of the cartographical enhancement to the positional data and will consist of the planimetric information with all generic text, patterns, symbols, toponymy, the contours and the surround. This file will be used to directly produce a paper map product. The file will be in IGDS format so that the data will conform to the Ministry's Intergraph System that is used for cartographic production.

4.0 QUALITY CONTROL

Once DMG started to produce data, the Ministry was faced with the task of ensuring that the data met the specifications. Given the amounts of data that are being produced, 40 sheets per month, and the complexity of the data, the only possible way to quality control the data was through a batch process.

With the experience gleaned from using the Intergraph system, the Ministry prepared a Request for Proposal that detailed the data processing requirements of the Branch.

This RFP was issued to some 10 companies, and as a result of the proposal evaluation, a short list of two companies emerged. Of these two companies, neither could perform the exact tasks that we required. It was decided that the Ministry would benchmark test the 'best' rated of the proposals to determine the likelihood of being able to modify the system to meet our demands. The first test of the CARIS software from Universal Systems proved to be quite educational for both parties. The software showed potential but was a long way from what we needed. The main problem was that the package was for data input to the GIS portion of the system. As such, the system batch processed, changed and manipulated the data to the point where it no longer represented the input. What the Ministry wanted to do was to **check** the data against the specifications and flag the areas where the software 'thought' there were errors. The second criteria was that there be a switch to provide for batch correction according to our rules and that the data not be changed. Universal Systems was intrigued with the TRIM specifications and data structure and undertook to make these changes to show the Ministry that the software could be easily modified to meet our requirements. Approximately two months after the first benchmark test, a second test was performed in Fredericton, New Brunswick. At the end of the week-long benchmark, the system was capable of meeting 90% of our requirements and the remaining 10% were software packages that would have to be developed.

Both DMG and the Ministry recognize the need to produce quality data in compliance with the specifications and thus the need for comprehensive, professional quality control. Great effort has been expended by both to ensure the integrity of the data. DMG and the Ministry have taken different approaches and this has led to the improvement of both systems; however, quality control remains an issue and will continue to do so throughout TRIM. Our best quality control will come from the users of the data. The earlier that the data is in the hands of the users for constructive feedback on the specifications and the adherence of the data to those specifications, the sooner that the Ministry can initiate any corrective action.

5.0 DATA DELIVERY SCHEDULE

By the end of the fiscal year 1988/89, the Ministry will have taken delivery of some 450 map sheets. The DMG is now approaching a production mode and can deliver 40 to 50 map sheets per month. In the northern part of the Province where the sheets are smaller and contain less detail, the production should reach 60 maps or more per month. This represents an annual production of 450 to 600 map sheets in the south and over 700 in the north.

TRIM data capture has been in the area of 103/P, 82/F,G,K. L and M. The program for 1989/90 has not been finalized; however, the greatest area of demand is in 93/A,B,G,H,O and P, 94/A,B,K,N and O, 103/I and the Queen Charlotte Islands.

To date the Ministry has received requests for some 4 000 map sheets. These requests are coming from a wide variety of users representing forest and mining companies, oil patch operators, survey firms as well as both provincial and federal governments.

6.0 DATA ARCHIVAL AND DISTRIBUTION

The quantity of data that TRIM will produce is quite significant. Each map sheet will be between 10 and 15 megabytes for all files. It is unrealistic to expect to place some 70 gigabytes of data on-line either for storage or distribution. The emerging technology for such is the optical disk medium. This could be in the form of compact disk (CDROM) or Write Once Read Many (WORM). The cost of the hardware is becoming quite affordable; however, the cost of producing the CDROM is still quite high. The attractive element of the CDROM is that it can be produced to be system independent. This would lend itself to data distribution. The WORM technology, due to the formating of the disk, is system dependent and is therefore more suited to archival.

The Ministry has developed a data compression routine that will compress the ASCII file to approximately 11% of its original size. Further testing of this software in a production mode is now occurring. Given that this proves successful, data transfer on high density floppy disks is not far off.

A pricing structure for the TRIM data has been set up such, that a Position or Representation file will be available through the MAPS-BC sale office at a price of $600 dollars per file.

7.0 CONCLUSION

The overall scope of the project is awesome when one realizes the area of British Columbia is the equivalent of central Europe including Austria, Belgium, Czechoslovakia, East & West Germany, Poland and the Netherlands. The Government of British Columbia has embarked on a very significant digital mapping program, one that will influence the direction and development of both geographic infomation systems and resource and environmental management.

It has shown that the technology has reached a state where it is possible for vendors to respond quickly to client requests and indeed this flexibility is becoming one of the important considerations in the evaluation of the request for proposal process.

The TRIM program will play a significant role in bringing British Columbia to the leading edge in the development, production and utilization of geographic information system technology.

GIS FROM A MANAGER'S PERSPECTIVE: PROBLEMS AND PROSPECTS

John Barker

Manager Forestry Technical Services,
Western Forest Products Ltd.,
Vancouver, B.C.

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Western Forest Products manages a forest land base of 680 000 hectares in coastal British Columbia. A substantial land use conflict and the accompanying analytical demands led to the decision by the company to implement a GIS to assist in management decision making. During the two years the project has been under way, management expectations have changed substantially and will likely change even more by the time the project is completed.

COMPUTERIZATION OF NATURAL RESOURCE INFORMATION IN THE NATIONAL PARKS OF WESTERN REGION

Patricia Benson

Resource Studies Manager - Western Region
Environment Canada - Parks
#520 - 220 4th Avenue SE
P.O. Box 2989
Station M, Calgary
Alberta, Canada
T2P 3H8

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

The Western Region of the Canadian Parks Service first began digitizing resource information in 1975 in conjunction with the comprehensive Biophysical Inventory of Banff and Jasper National Parks. The cartographic and data management subsystems of Canada Agriculture's mainframe information system, CanSIS, were used for this and subsequent inventories. In the early 1980s a series of national studies were undertaken to overcome the time, distance and resource constraints that were limiting the use of the data by park wardens who have the responsibility to manage the park lands. Tydac's SPANS was adopted as the national standard for microcomputer-based GIS for Resource Conservation located at regional and field offices. The presentation concludes with a summary of ideas that permits successful integration of the new tool into the Natural Resource Management Process, such as training, users groups, outside research and coordinator's role.

INTRODUCTION

In response to recommendations emerging during the public hearings on preliminary master plans for the mountain parks, in 1970 our minister announced a national policy to acquire a resource inventory for each national park as an essential step in preparing park master plans. A modified biophysical approach (ecological land classification) was the adopted method to provide an integrated landform, soil, vegetation and wildlife inventory at a scale of 1:50 000 with data presented in map and report format. We commissioned CFS, CWS, AIP AgCan, and AES as the lead agencies in obtaining this data according to our terms of reference.

The early involvement of a computer system for storage, manipulation and retrieval of data was desirable. Because CanSIS (Canada Soil Information System, Canada Ag's mainframe) was available, because it was willing to commit pedagogical expertise to our field teams and because we were not prepared to comprehensively evaluate all other systems, CanSIS was selected.

In 1975 the first spatial data was entered into CanSIS. By 1979 we had remote access to database for tabular reports. The first computer terminals for Resource Conservation were installed at park offices in early 1981. The Day/Tomlinson report "Does Parks Canada require computers to handle resource (including geographically referenced) data?" appeared in November 1981. One of their recommendations stressed the need to improve computer access to the large body of ecological (biophysical) data.

Here is where I think you will be most interested in our activities.

Even with the mainframe Geographic Information Systems (GIS), it was evident by 1983 that we lacked the delivery of EDP support to end-users, the park wardens. Despite remote access to the tabular data as early as 1979, access to the cartographic files always entitled a 6-week to 3 month turnaround. Park staff write or phone a distant office, then wait several weeks for plots only to realize that they hadn't posed the right question. It is no wonder that this large body of computerized data would be grossly underutilized. In practise urgent environmental analyses fall back on the old manual ways or personal knowledge.

Then in 1984 headquarters completed the Welch/Simmons study which examined opportunities for local processing as an adjunct to central facilities and recommended generic configurations. This was followed by a needs analysis study in 1985. Key points were whether and which micro-GIS to adopt as a standard and how it should relate to the systems we have used so far. The mainframe GIS should continue to provide us with main input, cartographic quality plotting and data archiving services. The mainframe databases would be considered the master and authentic versions. Micro-GIS's should be a data query and analytical tool at field and regional offices; acquisition should proceed when a commercially marketed micro GIS was available.

It was in June 1987 that headquarters completed its assessment of GIS hard/software on the market and selected SPANS for parks to use. We believe that standardizing on one product will simplify training, mobility, and interpark sharing of expertise; regionally we will be better able to coordinate links to existing computer services.

AVAILABLE DATA

Our computerized biophysical data has three, relatively static principal components. The first is the cartographic subsystem for handling data in map form. The initial use of this subsystem allowed printing of all maps but now its main focus is to produce derived or interpretive maps for specific uses. The second and third components utilized the data management subsystem of CanSIS to handle the extended legend (parameters applicable to the entire polygon) and the site measurements. The format was simple to understand and access for users without extensive computer training, yet sufficiently powerful for increasingly complex requirements.

Parks data on the data management subsystem include:

- the extended legend plus the number and extent of map areas, and other thematic data (the attribute file)

The third component contains point data:

- detailed descriptions of the soil, vegetation and wildlife resources that were collected at specific "characteristic" sites, that include many more features than appear on the computerized legend
- data files that include the date of sampling with each parameter so that a study and analysis of changes with time could be carried out

- special purpose files (eg. avalanche data, fire permits, enforcement action) being developed by wardens
- a wildlife observation file

At GIS conferences and workshops it is common to hear that map input accounts for 30 to 60% of the total cost of a project. Therefore it was important for us that downloading of cartographic files from CanSIS occur. CanSIS converted to minicomputer-based ARC/INFO and it is through this system that we are exchanging digital data.

More than 20 500 sq km of national parks in Alberta and B.C. have been digitized and accompanied by a biophysical legend. Another 2000 sq km have been digitized with a modified biophysical legend. The largest national parks have 13 000 map polygons; the others have 3 000, each described by up to 70 variables including geology, landform, soil, vegetation and wildlife parameters. Point data consists of 187 000 records of wildlife observations generated by park wardens on patrol, each coded for location, species, behaviour, weather, surroundings, etc. In addition, there are thousands of site specific measurements.

COORDINATOR'S ROLE

My responsibility does not require me to focus on products and projects, but rather on a data management system for supporting these activities. The Resource Studies office has been developing a regional network of cartographic and tabular databases having compatible data formats and operating procedures. The activities of the Resource Studies office are gradually changing to reflect the increasing demands both in the parks and in Regional Office to enhance and interpret biophysical information in combination with other land related data and to prepare maps, reports and decision-inputs specific to a resource management problem.

A basic objective in the Western Region is to provide 1 GIS workstation for each park, to be used by the warden service. This works out to 10 units. Ideally we strive for consistency of hardware and will define an appropriate amortization period for a workstation or its components.

Data manipulation can range from a simple selection and listing of a few records to a full statistical analysis. This range in capabilities is achieved by utilizing the same structure for all files - once a user has learned the techniques to access and manipulate wildlife data he can use the same techniques to select and manipulate biophysical information.

By sharing data among all users and ensuring that all users are using the same database, redundancy can be greatly reduced. There is no longer disagreement among the offices as to which copies are authentic. The centralized database is accessible to all and formally updated. Data are stored in the simplest form they can take. We chose the formal updating route in order to ensure we maintain the original integrity of the database.

The comprehensive resource inventory is one step in a standard Natural Resource Management Process. From the inventory stems resource analysis, resource planning and monitoring actions such as fisheries management, forest fire control, or major predator management. These actions are usually prescribed in each park's Conservation Plan. Use of a GIS is appropriate at all stages.

The headquarters' studies determined that our GIS applications include resource management, environmental impact assessment, monitoring, planning, development activities, research, regional analysis, etc. CPS essential needs have been determined as topological overlay, attribute selection and display, map reclassification, statistical analysis of attributes. Those functions likely to become important are adjacency analysis, network analysis, linking spatial data to mathematical models, generalization and corridor analysis. Those rarely used and not needed were density analysis, pattern recognition and 3-D drawings.

Computer capability is required in the parks to allow them to handle project oriented data, as well as to manipulate biophysical data, be it for the whole park or a windowed area. The actual data will normally be most actively used during the project (1 to 3 years) after which time data summaries will be transferred to Region. The parks will maintain temporary, unofficial updates of maps and files.

Regional capability is required to upgrade existing biophysical data and collect data required for new interpretations, as well as the capacity to input to interpretation plans and management plans. We will participate with parks to priorize upgrades or developments needed for SPANS. Region will coordinate data transfer/exchange

(eg. inventory data on adjacent provincial lands, university research), to assess potential uses and problems. We will facilitate transfer of parks data for manipulation on other GIS's for those features not contained in SPANS. The Region will assist parks with defining needs for other computer systems that SPANS is not designed to handle (eg. 3-D modelling for ski area development).

The mainframe will continue to be used for maintaining an archive of biophysical inventory data in standard digital formats, for plotting, colour printing, and production of cartographic quality products, and for digitizing new data from maps considered to be part of the master database.

RESEARCH

The Region will initiate, encourage and support research activities using National Parks databases, especially any cross-disciplinary research efforts. Sample topics include:

- research to enhance the acceptance of GIS both by wardens and senior managers.
- research that improves the practice, effectiveness and rigour of the use of GIS tool in resource management. post analysis reviews, systematic audits or other studies which compare decision inputs with and without a GIS - developing new approaches to integrating other data (socio-economic, landsat) data into the existing computerized framework of biophysical data.
- personal research pursuits where the researcher is committed to presenting his data within our biophysical classification, thereby allowing us to incorporate this new data into our existing framework.
- formats and procedures for simplifying data exchange

TRAINING

The nature and tasks of implementing, using and managing a GIS required exceptional individuals. You cannot simply define the right project managers and wardens and pull them off of the university, government or private shelf. GIS development and management is an evolving and often times discouraging process.

Training the user to interact with the system is important to the success of an information system. A graduated system of demonstrations and hands-on seminars have been prepared and are conducted to develop the required level of expertise to allow the individual user to access and use the data for specialized needs. Most park wardens, naturalists and their managers have learned to carry out data selection and display procedures interactively. Many are being trained to use more sophisticated analytical capabilities. A group use the spatial modelling language for complex problems (ecosystem modelling uncertainty adds to their confusion). As we want him to get exactly the output needed and to use the information that is relevant and appropriate, training addresses the requirement for good understanding not only of the data and the techniques to manipulate it, but in using it in the context of resource management.

USERS' GROUP

We have formed a Users Group composed of a warden from each park, CPS regional staff, and a CanSIS representative plus ad hoc members from external agencies who participate as necessary. Some of the key objectives include:

- to upgrade the skills of the group - to become aware of people with advanced computer analysis
- to criticize the use of the tool in resource management
- to be a large and firm voice for feedback to the software vendor
- to exchange applications at users' meetings and in newsletters
- to keep management and other levels of the organization (at the park and in region) informed.

SUMMARY AND FUTURE

Regional office creates and maintains an organized database of geographic information for continuing use by a variety of users rather than for specific project applications. The database is created for long-term use so that the processes of updating and training are of great importance. The aim is to create an integrated data resource which will be useful over a long period of time for a wide variety of users.

A FRAMEWORK FOR INTEGRATING SILVICULTURE SURVEY WITH DATA ANALYSIS, PLANNING, AND DATABASE UPDATE

David G. Brand

Petawawa National Forestry Institute,
Chalk River, Ontario
K0J 1J0
(613)-589-2880

Al Becker

British Columbia Ministry of Forests,
Inventory Branch,
1319 Government Street,
Victoria, B.C.
V8W 3E7

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Management of public forest land requires large information management systems to support decisions at the stand level, forest level, and even provincial level. These information systems currently include field surveys for stand level decision-making and forest inventory for whole forest or timber supply area analysis. Field survey data can be used to update inventory information, but there is currently limited ability of field staff to access the central information system to assist with work planning or map production. A prototype system, designed to automatically collect field data on plantation performance, analyze the data, send output files to the central GIS, and produce field maps with the GIS, is described. A field trial was conducted in the Squamish Forest District (Southwestern B.C.) with this system and an interface written with PAMAP software to allow district level map production. Future developments of these types of systems will allow much more effective use of field survey data and allow improvements in planning and work scheduling at the field level.

INTRODUCTION

The provincial governments of Canada control vast areas of forest land. The ultimate responsibility for this land base and the attendant large public capital stock and investments is borne by provincial agencies. Some common features of public land management systems are large amounts of data on various aspects of the forest and its use, flow of data from small administrative units to larger units, and integration of data from different sources and to different levels of resolution (i.e. from the stand level to the forest level to the provincial level). Although desirable, public systems currently do not allow flow of information back from centralized systems to the field level very easily, and are not two-way information systems.

Geographic information systems hold great promise for developing spatial database management systems allowing two-way information exchange. By imposing a common geographic referencing scheme, the GIS allows several layers of information to be held on a given area of forest land, and can act as an information storehouse and retrieval system for both strategic analyses and stand level planning. The use of GIS in Canada is in its infancy; most provinces are in the process of completing the digitization of mapsheets. Only British Columbia has reached a point where the GIS has begun to be used for timber supply analyses. Therefore, the development of forest management systems using the GIS software is still open ground. Many proposals have been made that would improve, for example, harvest scheduling or the prediction of insect outbreaks.

One promising area of improvement, using a geographically referenced database, is silvicultural planning. Silviculture programs are planned, carried out, and audited at various levels. A field survey of a clear-cut block, for example, could be used for a planting prescription, for determining nursery stock sowing requests, for summarizing the NSR (Not Satisfactorily Restocked) land base of a district or region, or for setting the regional or provincial allowable cut. Using GIS, the road access, terrain, and size of the area could be identified and used to rank the block against others for treatment priority. In this paper we will outline work to date on a prototype system for regeneration assessment that demonstrates some of these facilities.

SILVICULTURAL SURVEY DATA-CURRENT PROBLEMS

Areas are currently surveyed for a variety of purposes to support silvicultural decision making. Common types of surveys include regeneration surveys to assess stocking of areas after harvesting or fire, survival surveys to assess plantation success, free-growing surveys to assess stocking and the need for brush control some years after harvest and reforestation treatments, and intermediate stocking surveys to determine the need for cleanings or thinnings in the stand. These surveys have generally been carried out using field cards and lead to single purpose decisions or descriptions. The results of the survey can be used to update a forest cover label, to form the basis for a silvicultural treatment, or as file information on the forest unit concerned.

These systems are inefficient for a number of reasons. The surveys collect a large amount of data that is summarized into simple statistics supporting a simple decision. The surveys do not provide adequate support for complex decisions or rankings of different areas for treatment and, therefore, the data collected tends to be single use. A regeneration survey, for example, could provide a new inventory map label for a given block, but the label on the base map cannot be automatically updated. Finally, the data cannot be readily combined with other important sources of information to synthesize economic or statistical information. For example, the stocking survey could be used for a simple decision on reforestation treatments, for updating a map cover label as mentioned above, or for strategic analysis against land tenure, physical site characteristics, access, etc.

The development of information systems that work at different levels becomes increasingly important as public investments in forestry increase and non-timber users demand accountability for those investments. The problem is not the amount of information collected. Forests are flown over for air photos periodically, surveyed three or four times on the ground during harvesting and regeneration, and inventoried on a five- or 10-year cycle. The problem is the use and management of the data. If the specific phases of data collection and use are examined it is easy to see that improved systems of data management are possible.

Field survey work increasingly relies on portable data collectors to produce automated reports, but the reports are often similar to those designed when staff were limited by hand calculation methods. More sophisticated programs of data analysis and summary can now be written that will make better use of the data collected. The increasing presence of personal computers in forestry offices and the computer literacy of recent forestry graduates now makes these developments feasible and desirable. The GIS systems currently in place are largely

used for forest inventory purposes, but are not linked with the silviculture surveys that collect up-to-date information on stand level conditions. To use the output from survey data analysis for automatic updates of the GIS polygon attributes of species composition, stocking, and even site class, should not be difficult.

TECHNOLOGICAL INTEGRATION: A PROTOTYPE

A survey system was described by Brand (1988) that allows description of plantation growth, stocking, and brush problems. The system uses a field survey based on software written in BASIC for the Husky Hunter. The data is internally formatted by the Hunter and transmitted to a PC or other secondary computer for analysis. This analysis software projects individual tree free-growing status, calculates average height vs. age relationships for free-growing trees, computes total stocking and free-growing stocking, and analyses spatial pattern or regularity in stocking. As well as tabular summaries, the system produces as output a file with UTM coordinates of survey plots including the total number of potential crop trees and the number of free-growing trees. This file includes titling information and a reference to the GIS mapsheet and polygon so that a field map can be produced and the polygon attributes updated. Within the area surveyed a spatial autocorrelation statistic is used to indicate whether stocking or brush problems are uniform or localized.

A PILOT STUDY

A trial was made of this system to determine its suitability for field usage and as a prototype for further operational developments. Four large clear-cut blocks were chosen in the Squamish Forest District, north of Vancouver, for semi-operational survey and analysis with the Husky Hunter program. The blocks were all located in areas where the base maps and forest cover types had been digitized into the B.C. Ministry of Forests' GIS system. The four blocks were surveyed in the fall of 1988 using both the Husky Hunter system and the conventional B.C. Forest Service free-growing survey protocols. The Husky system is not directly comparable to the current survey system, as extra data are collected on the growth of the crop trees and competing vegetation. The field test found that the Husky Hunter survey for a given block took approximately three times as long to complete (*P. Rehsler, pers. comm.*). The major causes of the extra time were some unresolved bugs in the Hunter software, the advanced age of the sites surveyed (9-15 years, making measurement of height and height increment difficult), and the extra measurements taken.

Analysis was undertaken on the data at the Petawawa National Forestry Institute using the FORTRAN program FREE.FOR. An example of the output for a particular block is shown in Table 1. The output files for the four blocks were then sent to the B.C. Ministry of Forests Inventory Branch for development of an interface routine to link with the digital inventory database through the PAMAP GIS software. The spatial location of each plot is provided in UTM coordinates in a data file that is transferred from the Husky Hunter. The coordinates and survey data are read from the diskette and a color coded symbol for each plot is created on a unique level of the forest cover file for storing regeneration survey data. The symbols vary according to criteria (e.g. competition) provided from the sample summaries. The system allows the operator to vary the class criteria used for creating symbols so that different summaries can be graphically represented. The system will automatically handle the input of opening data that spans more than one mapsheet. All data associated with each plot is available for linking with the rest of the data in the inventory file through the overlay process provided by the GIS. Thus the operator can produce the standard output described below or do more elaborate analyses utilizing the full range of attributes and graphics in the inventory file and the options in the GIS.

Once the data has been input to the inventory file the opening polygon vectors, polygon label, sample plots and other information such as roads and creeks can be extracted and plotted. The area of interest can be interactively highlighted by using the cursor or by inputting the coordinates of the corners of the area of interest. The area is extracted and merged with header data that was input on the Husky Hunter for each opening. The legend and symbol table are generated and the final combined data is routed to a plotter for hardcopy output. The plot is produced at a scale of 1:10 000; however, a wide range of scales can be selected. The system utilizes menu choices, interactive edit capability, and batch processing to provide an automated and user friendly interface.

The final package is a set of summary tables, including derived statistics and a map showing the distribution of sample plots colour-coded by stocking and degree of brush competition. Final evaluation of the system and its potential for operational development will be made during 1989.

As with any new technology, this type of systematic data collection, analysis, and management will require considerable fine-tuning, redesign, and training to become integrated with current operational practices.

Revisions to major systems cost a great deal and the changeover must be designed to cause a minimum of disruption and confusion, but still achieve cost or management efficiencies. In this case, the availability of new technologies at the field level, including the portable data collectors, personal computers, and GIS interface, make former survey systems obsolete. It is important that the new survey systems implemented take full advantage of the new technology and not just computerize the old manual methods.

Looking ahead to the day when all surveys in a given district such as Squamish are systematized, designed to link with a single database, and tied into various growth projection models and a GIS, several benefits can be foreseen. First would be the simple savings in manual data keying, proofing, and transfer. More importantly, systems could be designed at the timber supply area level that would analyze opportunities for silvicultural investment and support work planning and budgeting. Finally, costs and benefits of silvicultural programs for timber production could be integrated with wildlife, fisheries, tourism, or aesthetic concerns more efficiently.

SUMMARY

There is the opportunity to revolutionize silvicultural data collection and management by the integration of currently available technologies. Key components of new systems should be direct data entry in the field, with the information collected designed to be analyzed by new software packages. Output of surveys should lead to the best possible prescription support at the individual site level, to automatic updating of land base status and attributes, and to the ability to carry out ranking or program planning in conjunction with the GIS.

TABLE 1.
EXAMPLES OF TABULAR OUTPUT

SUMMARY OF COMPETING VEGETATION FOR CALLAGHAN CREEK AS OF 11-02-1988

SPECIES	FREQUENCY (% trees)	AVERAGE CANOPY HEIGHT (m) CURRENT	PROJECTED
CLASS 1: HERBACEOUS			
Epilobium angustifolia	4.7	1.37	1.37
Pteridium aquilinum	1.3	0.90	0.90
CLASS 2: LOW WOODY BRUSH			
Alnus sinuata	2.7	2.06	2.56
Menziesia ferrugina	0.7	2.48	2.62
Taxis brevifolia	1.3	1.85	1.90
CLASS 3: TREE-LIKE BRUSH			
Alnus rubra	7.4	9.52	9.94
Populas trichocarpa	1.3	12.00	12.81

STOCKING SUMMARY AND FREE TO GROW STATUS FOR CALLAGHAN CREEK
AS OF 11-02-1988

SPECIES	PLANTED/ NATURAL	AGE	PLOTS WHERE PRESENT	TOTAL PLOTS	TOTAL STOCKING (stems/ha)	FREE TO GROW STOCKING (stems/ha)
UNIT: 1 Flat						
Abies amabilis	N	6+	3		66.67	44.44
Pseudotsuga menziesii	N	5	1		22.22	22.22
Pseudotsuga menziesii	N	6+	6		333.33	288.89
Thuja plicata	N	4	1		22.22	0.00
Thuja plicata	N	6+	6		177.78	155.56
Tsuga heterophylla	N	6+	5		222.22	200.00
TOTAL FOR UNIT 1				9	844.44	711.11
UNIT: 2 rolling						
Abies amabilis	N	6+	21		351.72	324.14
Pseudotsuga menziesii	N	3	1		6.90	0.00
Pseudotsuga menziesii	N	6+	5		41.38	27.59
Thuja plicata	N	3	1		6.90	0.00
Thuja plicata	N	4	1		6.90	6.90
Thuja plicata	N	5	1		6.90	0.00
Thuja plicata	N	6+	10		96.55	89.66
Tsuga heterophylla	N	6+	18		248.28	200.00
TOTAL FOR UNIT 2				29	765.52	648.28
STOCKING SUMMARY				38	784.21	663.16

REFERENCE

Brand, D.G. 1988. **A Systematic Approach to Assess Forest Regeneration.** For. Chron. 414-420.

USING GIS TO IDENTIFY AGRICULTURAL SOILS SUSCEPTIBLE TO SALINITY DEVELOPMENT

Dennis L. Corwin, Ph. D.

Soil Scientist
U.S. Salinity Laboratory
4500 Glenwood Drive
Riverside, CA 92501, U.S.A.

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT OF POSTER

Maps are presented which delineate areas of low, medium and high salinization potential on irrigated, arid-zone soils of the Wellton-Mohawk Irrigation District near Yuma, Arizona. The salinization potential maps are the result of coupling an automated GIS, ARC/INFO, to a multiple linear regression model which relates soil salinity to edaphic and irrigation management factors. Specifically, soil salinity is related in a linear manner to three regressor variables: leaching fraction, groundwater electrical conductivity and soil permeability. The "best fit" multiple linear regression model related soil salinity inversely to soil permeability (cm/hr), inversely to leaching fraction, and directly to groundwater electrical conductivity (dS/m) with regression coefficients of 18.03, -0.4, and 1.32, respectively, and a stochastic or error term of 2.12. A comparison of predicted soil salinities from the multiple regression model to measured soil salinities showed a high level of correlation with a slope of 1.0, a y-intercept of -0.001 and a r2 = 0.81.

GIS - IS IT COST-EFFECTIVE?
A CASE STUDY

Don Couch R.P.F.

Silviculture Forester
Riverside Forest Products Ltd.
RR2 Lumby, B.C.
V0E 2G0

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

When proposing to purchase a GIS, the one major question that needs answering is: What is it going to save me? This paper focuses on a case study of how one organization dealt with this question. Riverside's Golden Rules for implemention are given to help save costs.

THE CASE STUDY

Riverside Forest Products Ltd. is a privately owned company located near Lumby, B.C. We operate a veneer plant, sawmill, planermill, and are part owners of a plywood mill in Vancouver. Our consumption is approximately 360 000 m^3/yr from provincial crown lands and 220 000 m^3/year is purchased. The company works in four Forest Districts and two Forest Regions, all different from each other. Our operating area covers 346 409 hectares.

During the recession our draughtsperson left the company. Most government departments and companies were down-sizing to save costs. Our woodlands division was asked to justify and quantify the need for a draughtsperson before a replacement would be approved.

This request provided a situation to evaluate what we did, why we did it and how we could do it better. Where did draughting fit into the organization? A system analysis approach was taken resulting in a revised job description. However, no money. We muddled through the next two years surviving without a draughtsperson.

At the same time, a staff member was back east and returned with stories of a new computer technology called CAD/CAM. After further reading, we were convinced that GIS could solve "all" our problems.

Riverside prides itself in analysis techniques but computer/software justification needed a whole new approach.

Using a standard cost/benefit comparison we examined how fast a draughtsman could copy a line compared to a computer at 16 inches/second, without breaking down. Through this approach a winner is decided by some number or a return on investment rate. We started, and drove people crazy timing how long it takes to colour a map or copy the average cutting permit application map. We thought we were moving in the right direction, but this approach showed very little.

A new method was needed. We then looked at what computers can do best.

1) they do repetitive tasks without complaining
2) they crunch numbers fast
3) they sort things fast
4) they draw and store lines.

A GIS including a data base manager does all of this and more. At this point, we concluded the key to a GIS is the repetition. It takes the same time to do a job the first time, whether using a computer or by hand. The difference is on the second or third time around, repeating the process with only a few changes to make a new map.

To make a different map by draughting, the original map and changes are all redone by hand. Using a GIS, a copy of the original map is made instantaneously and only the additions are made using the computer. From our original work back in 1983 we could see the advantage of layering maps on top of each other. Different combinations would produce "all" the maps we required.

A sampling of how a base map can be used may include:

1) Development Plan Map
2) Pre-Harvest Silviculture Prescription Map
3) Mountain Pine Beetle recci map and infestation source
4) Road Permit Application Map
5) Cruise Application Map
6) Cutting Permit Application Map
7) Long and Adverse Skidding Map
8) Contour Map
9) Annual Report Map
10) Plus a huge potential for amendments and/or changes and maps for planting, survival studies, stocking surveys, brush and stand tending results and on it goes.

For each of these maps we also required three to ten copies.

Riverside harvests approximately 100 cut blocks per year with an average block size of less than 10 hectares. With this much information to keep track of we found that our manual system was getting out of control.

By putting layers of information together we would be able to produce a majority of these maps quickly, while increasing our consistency and presenting a quality product. We calculated that we would save approximately 10 hours per cutting permit per year which is 7 1/2 weeks saved in operational mapping alone when you process 30 cutting permits a year.

Armed with this, the marketing job to the company owners started. This was a long-term project including weekend demonstrations for the owners and a lot of patience and cooperation from the software supplier, Dan Lemkow of Digital Resources. We eventually received approval for the concept along with an improving economy.

Just a comment; it is nearly impossible to prove, using an accounting analysis, the benefits of a GIS. This is because of the unknown future spin-offs. It should be recognized that reducing implementation costs will eliminate most of your problems and save money. Reducing cost is different for a GIS system than what most people would expect.

We offer Riverside's Golden Rules:

1) buy the fastest computer you can, it will not be that fast next week;
2) buy as much memory as possible, there never is enough;
3) buy a "good" software package that other people are using. It is nice to know others are going through the same problems;
4) buy your software from someone who speaks English, and not "Computerese";
5) hire the best operator you can find and then keep them very happy;
6) plan the first project carefully, it could be your last;
7) let your imagination go.

Follow-up is necessary for the person who signs the cheques. Get them involved, show them the fancy machine and then produce something quickly.

Our first project was our operating area map, it was completed and hanging on the owner's wall within two weeks. Since then, using this same map, a further twenty versions have been produced showing a variety of information. During our first year, we concentrated on mapping. The system is now fully integrated into our day to day mapping requirements. The second year was spent cleaning our operating area data base and using the information for planning purposes. Today we are spending our time merging these two functions together for TSA re-analysis, continuous history requirements and Ministry of Forests' reporting systems.

IS GIS COST-EFFECTIVE?

To say if GIS is cost-effective requires further observation. Initially the timesaving comparison between maps generated manually or by computer was a major selling point. Within two years this has been forgotten.

The value of the system is now determined by asking:

1) Has anyone out there sold off their GIS and gone back to their old ways permanently?
2) What is the value of information?
   i) What is your species distribution and average diameter?
      Do you have the right mill for the future?
   ii) What is the age class distribution?
      Are we spending our intensive dollars wisely to increase our cut?
   iii) How much timber is there anyway?

3) What is the value of a clean and accurate map?
4) What is the value of improving your planning process for develop ment plans and reducing other resource user conflicts?

Your system will start to grow, being used for projects that you never dreamed possible before you purchased it.

Let your imagination go:

1) Put your cursor over your base map and push a button, instantly a list of contact people including ranchers, community watershed holders, miners, trappers, guides and other users all appear on the screen. Push another button and letters are automatically printed and addressed to the individual about your future harvesting plans.

2) A continuous history system that prints out maps and lists areas requiring stocking surveys, listing out the stocking standards and goals for each cut block.

3) Imagine proposing a cut block and receiving a printout based on your attribute files identifying critical wildlife concerns by species, while giving harvestable volumes, species distribution and road cost projections.

SUMMARY

In summary, the benefits to Riverside has meant not only doing a job cost-effectively, but attempting projects and accessing information we never dreamed possible when we started our clumsy analysis. The system helps to give confidence in our planning decisions.

A GIS is like a compass to a sailor, it opens up a whole new world.

INTEGRATION OF GIS AND PHOTOGRAMMETRY

Al Daykin

General Manager
Digital Mapping Group Limited
Burnaby, B.C.

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Creating and updating digital maps using photogrammetric techniques is a cost-effective method of acquiring digital spatial data for use in Geographic Information Systems. This paper deals with some of the technical and managerial considerations in the acquisition, training and implementation of a digital photogrammetric data capture system, some of the problems associated with acquiring and supplying spatial data to GIS users and the related benefits of photogrammetric techniques.

THE FOREST RESOURCE ANALYSIS SYSTEM: A GIS-BASED DECISION SUPPORT SYSTEM

Lois H. Dellert

Manager, Forest Resource Analysis Section
Ministry of Forests
Inventory Branch
1450 Government Street
Victoria, B.C. V8W 3E7

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Resource management in B.C. is evolving as a result of changing issues, better resource inventories, increased knowledge and improved technology. Current timber supply analysis systems are primarily long-term sustained yield oriented and not area specific. These systems are no longer meeting managers needs in several key areas including integrated resource management, location and scheduling of 20 year timber supplies and in reconciling the actual harvest with the forest inventory. The Forest Resource Analysis System (FRAS) is an area based interactive decision support system for local managers which addresses these key areas.

INTRODUCTION

Timber Supply Areas (TSAs) are the basic strategic planning units of Crown-managed lands in British Columbia. Resource management planning for TSAs coordinates provincial resource policies, regional priorities and local resource requirements to determine management strategies and production targets for timber, range and recreation.

This planning process is supported by resource knowledge and data as interpreted by various analyses. The present analysis system is based on resource issues, our understanding and technical capabilities of ten years ago. Since that time resource management issues have evolved along with our understanding and significant advances in technology. Consequently, the structure of the TSA analysis system is out of date.

The Forest Resource Analysis System (FRAS) outlines a new analytical system and approach to support resource planning. FRAS is an analytical framework which coordinates existing systems and models and provides guidance for the development of new systems and models.

CONCEPTS

FRAS addresses current resource management issues including integrated resource management, economics of timber supply, impact of wildfire and pests, incremental silviculture, linkage of strategic plans to operations, monitoring the inventory with the actual harvest and provision of analytical capability for local resource managers. It builds on existing knowledge and resource inventories and incorporates new technology including Geographic Information Systems (GIS).

The key concepts of FRAS are:

Area-Based

FRAS is an area-based system which considers the geographic location and spatial relationships between stands. That is, the basic resource data will be organized and maintained on an area-specific basis rather than the largely strata-based approach of the current system. An area-based approach maintains geographic fidelity regardless of the level of aggregation and therefore permits strategic plans to be linked to operations. It is essential for analyzing other resources which flow from a specific geographic area and not from a strata expressed as an aggregation of similar forest cover types. It is also important for harvest scheduling since harvest production patterns are spatially oriented.

Integrated Geo-referenced Data

Resource data will be geo-referenced and will be integrated such that all resource information for a specific area can be collated to provide resource managers with a composite resource "map" and data for any area. This will require mapping and data standards within and across resource management agencies and is essential to the implementation of FRAS.

Open Design

The framework provides an open and flexible design which facilitates the integration of additional planning models and resource data from different sources. It will also permit the system to evolve and expand as technology advances, as additional resource data is collected and as resource issues evolve. The open design will permit easy data exchange between different GIS systems and standard microcomputer applications such as spreadsheets, graphics and word processing.

Short and Long-Term Timber Supply Analysis

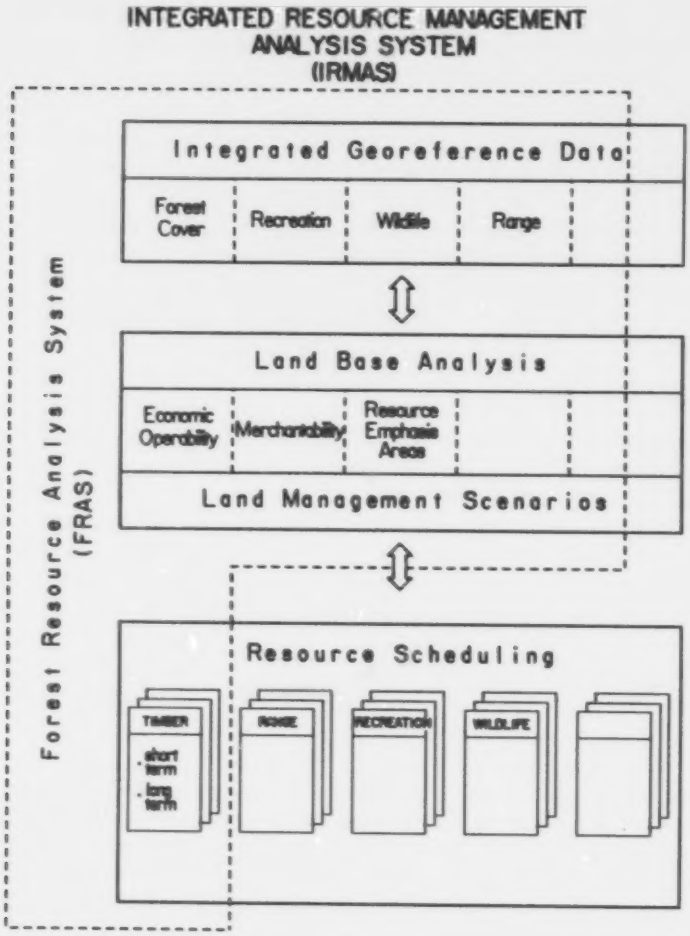
Both short and long-term timber supply analysis will be incorporated. The short-term analysis generates operationally feasible twenty year timber supply schedules and the long-term analysis assesses long run sustained yield. The short and long-term analyses will be linked to ensure the sustainability of short-term strategies and to provide direction for the implementation and monitoring of strategic decisions.

Local Decision Support

FRAS will be implemented as a decision support system in the Regions and Districts. It will provide local resource managers with tools to analyze the multitude of issues and questions that arise on a regular basis. The tools will include a GIS plus various models and procedures. System interfaces such as menus and windows will be developed.

Design

FRAS is a part of a larger conceptual framework, The Integrated Resource Management Analysis System (IRMAS) which integrates all resources. FRAS includes the components of IRMAS which include timber supply analysis (Figure 1).



The components of FRAS are:

Integrated Geo-referenced Data

FRAS will use integrated geo-referenced data for all resources including timber. This component of FRAS is a data inventory component and is not strictly speaking part of FRAS. It has been included to identify the linkage to inventory, our evolving need for site-specific integrated resource data and to emphasize the importance of data standards across all resource agencies.

Land Base Analysis

Land base analysis uses integrated geo-referenced data, local knowledge and resource objectives to generate alternate land management scenarios. Each land management scenario will identify the land base available for timber harvesting and specify the spatial, temporal and integrated resource management constraints on harvesting.

A GIS will be the primary analysis tool and will link to various models. One example of a model is the Coastal Economic Stock Model (Williams, 1987) which provides information on timber harvesting operability. Other resource models such as water flow and wildlife habitat models can also easily be linked.

Land base analysis is not a well defined or structured program. It requires interaction between local managers and the GIS analysis tool which is used to overlay, graphically display and report on alternate strategies. The local manager uses this tool to make decisions on feasible land management scenarios which are then input to the various resource scheduling models including short and long-term timber supply models.

Short-Term Timber Supply Analysis

The short-term analysis will for each land management scenario, allocate and schedule a feasible twenty year timber supply for each operator in the TSA.

For geographic sub-units within a TSA, feasible timber harvesting production patterns and potential harvestable volumes available will be developed for a twenty year period. These production patterns will recognize other resource considerations as identified in the land base analysis. The harvest will be scheduled by allocating geographic sub-units and selecting a combination of production patterns which provide each operator with sufficient harvest for twenty years.

Long-Term timber Supply Analysis

The long-term timber supply analysis evaluates the mid and long-term impact of the area-specific short-term harvest schedule. It also assesses the long run sustained yield impact of alternate management strategies which are primarily growth oriented such as incremental silviculture.

The short-term area-based harvest schedule will be imposed on the first twenty years of a two hundred year planning horizon. The long-term analysis will be primarily strata-based but will maintain sufficient area based resolution for the first twenty years. The long-term analysis will incorporate both simulation and linear programming techniques.

The output will be long-term harvest schedules, inventory reports and management strategies.

Reconciliation

A short-term harvest schedule may worsen mid and long-term timber supplies; the long-term timber supply may indicate that the allowable annual cut (AAC) can be increased, or the short-term analysis may indicate that the AAC can not be implemented operationally. The short and long-term analyses must be reconciled to ensure that the AAC is operationally feasible and that the short-term harvests will not adversely affect long-term timber supplies. Reconciliation is an iterative process that may require revising short and/or long-term analyses and as well as developing revised land management scenarios.

Monitoring

Monitoring of the actual harvest with the inventory and the plan will be enhanced by the area-based approach in FRAS. Actual operations can be linked to the inventory through satellite image analysis and compared to the resource management plan using FRAS.

SUMMARY

The Forest Resource Analysis System, part of the Integrated Resource Management Analysis System, is a framework which describes a new approach to resource analysis.

This new approach incorporates a decision support system for local managers which is centred around a GIS and integrated georeferenced data. It is an area-based system with an open design which permits other resource models and data to be incorporated, links short-term harvest to long-term sustained yield and provides resource managers with the information they require to address today's issues.

FRAS will provide the basis for our next decade of development and analysis.

REFERENCES

Williams, D., L. Dellert, and P. Bunnell. 1988. **Proposed Forest Resource Analysis System (FRAS), Problem Analysis and System Concepts,** B.C. Ministry of Forests, Inventory Branch. August 1988.

DEFINING THE OPERATIONAL FOREST INVENTORY FOR HARVEST PLANNING WITH A GEOGRAPHIC INFORMATION SYSTEM

Duane R. Dippon, Robert Wright and Robert Metzger

Oregon State Office
Bureau of Land Management
Portland, Oregon 97208

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

The Western Oregon Districts of the USDI Bureau of Land Management are developing a 7 million acre Geographic Information System. Concurrently, they are involved with a 10-year harvest scheduling planning effort for the 1990's. This paper presents an overview of how the relational and spatial databases under development will be incorporated into the current strategic planning process, as well as future tactical operational planning and general management activities.

INTRODUCTION

The U.S. Department of the Interior, Bureau of Land Management (BLM) administers the use of a wide range of natural resources on nearly 2.4 million acres in western Oregon (USDI, 1984). BLM-administered lands in western Oregon include the 2.1 million acre revested Oregon and California Railroad lands, approximately 239 000 scattered acres of the public domain, and nearly 75 000 acres of reconveyed Coos Bay Wagon Road lands. These areas support some of the most productive forests in the world, which in turn contribute to the economic well-being of western Oregon. While forest management traditionally focuses on timber production, important natural resource commodities including wildlife habitat, streams with resident and anadronomous fisheries, designated natural areas, and opportunities for many recreational activities are provided as an ancillary result of forest management.

Because timber management represents such an important issue, The Oregon and California Sustained Yield Act of 1937 was conceived to guide the management activities of public lands under BLM jurisdiction. The O&C Act states that the lands administered under the Act...

> *"shall be managed for permanent forest production, and the timber thereon shall be sold, cut and removed in conformity with the principle of sustained yield for the purpose of providing a permanent source of timber supply, protecting watersheds, regulating stream flow and contributing to the economic stability of local communities and industries, and providing recreational facilities" (USDI, 1984).*

The Federal Land Policy and Management Act of 1976 (FLPMA) further emphasized the need for management practices to comply with multiple use issues and sustained yield principles. As part of the implementation of these two acts, BLM is required to calculate the allowable harvest level for commercial timberlands. Timber management plans are recalculated every 10 years. Formulation of a new plan involves extensive re-inventory activities, planning, and appropriate levels of environmental analysis. Secondary program elements, such as the control of competing vegetation or other silvicultural treatments, are also studied and their worth included in the decision making process. This major planning effort requires numerous pieces and types of data from many diverse sources. Lack of accurate data and precisely mapped planning documents can have a devastating effect on the implementation of any future forest plan. Because the methods, assumptions and implications of the planning effort are open to ever increasing public scrutiny, and with the litigation of most of the USDA Forest Service Plans in the Pacific Northwest during the past decade, traditional procedures appear inadequate. A new and different procedure has been implemented in western Oregon by the BLM for the development of Resource Management Plans (RMPs) for the 1990's.

The new planning strategy which the western Oregon BLM has adopted relies on the availability of spatial and relational data which can be manipulated to evaluate spatially oriented natural resource management policies. A Geographic Information System (GIS) is expected to provide natural resource planners with the capability to employ a highly complex inventory data base for the appraisal of a variety of policies in an efficient and timely manner.

TIMBER MANAGEMENT FOR THE 1990'S

To meet the legislative directives listed above and manage the lands under its jurisdiction, BLM has undertaken two significant and coincidental tasks. Planning teams from six BLM Districts have embarked on developing separate management plans, referred to as Resource Management Plans (RMPs), for the twelve Sustainable Yield Master Units (SYMUs) in western Oregon. A SYMU is legally defined as a geographic area where the management is predicated on providing long term sustained yield for local timber markets. Districts may have one to four SYMUs under their jurisdiction. Actual physical management occurs at the Resource Area (RA), a sub-district administration unit. The geographic boundary of an RA does not necessarily coincide with that of a

SYMU. This variation in planning unit versus management unit definition has occurred over time with RA boundary modification to provide efficient management areas while the SYMU boundaries have remained fixed. The strategic planning process, here referred to as Timber Management for the 1990s', consists of a combination of activities including the design of alternative management scenarios, simulation of management through harvest scheduling analyses, evaluation of analytical techniques for measuring effects, reporting, public input and plan implementation with strategies for monitoring, maintenance and evaluation. The development of the 1990 plan is predicated on the availability and utilization of data from the Western Washington Digital Database (WODDB) Project.

With this data, the GIS will be instrumental in calculating the operational inventory acreage for the alternative management scenarios defined in the planning process as defined in the State Guidance (USDI, 1988). Formulation of the management blueprint in the RMP with the GIS creates the opportunity for developing and documenting resource management opportunities, identifying management problems or land allocation conflicts, and developing an array of reasonable alternatives for analysis. Public involvement and participation, as well as interagency review for plan, program, and policy consistency, is not only essential, but required throughout the analysis and decision making process.

The RMP process, as presently defined, does not attempt to determine the analytical optimal land use allocation for each of the SYMUs. Rather, the planning process evaluates the harvest scheduling and environmental impacts of alternative management directives. Theoretically, alternatives which "best" meet the expectations of the political world in which the plans must be adopted will be adopted.

The methodology as defined by the State Director Guidance (1989), first specifies goals for natural resource protection through spatially oriented restrictions on the commercial timber base. Once the commercial inventory base has been redefined by the predetermined restrictions, timber production is estimated based on expected silvicultural treatments and biological potential. The proposed analysis is better represented by an analogy to conducting a "what if ?" type question and answer format rather than seeking the "optimal" solution.

If the Bureau is to be successful in evaluating the many alternatives and variations which will be defined in the planning process, the proficiency for reporting the impacts of spatially defined issues on the acreage in the operational inventory is paramount. The development of a link between the databases and the harvest scheduling model represents a prerequisite if the planning process is to succeed. No such union of models currently exists although the elements are currently available. The approach described in this paper represents an initial phase in the development of a fully functional system. However, before the software can be utilized, the digitized database must be defined and captured.

THE WESTERN OREGON DIGITAL DATA BASE PROJECT

The Western Oregon Digital Data Base (WODDB) is a project initiated in 1985 for the construction of the digital database required for the support the RMPs planning process as well as to provide a database for future tactical or operational planning activities. The database is scheduled for completion in 1990 on BLM-administered lands in western Oregon (Wright and Pearson, 1988). It involves digital mapping of over 7 million acres at a scale ranging from 1:4 800 to 1:2 000 000 with 75 base and thematic layers. The detailed timber data coverage will only be completed for the 2.4 million acres which comprise the BLM commercial timberlands in western Oregon. The following table identifies the themes and their scales for the current configuration of WODDB.

DESCRIPTION	MAPNAME	UNIT OF COVERAGE	INPUT SCALE
BASE THEMES:			
Transportation network	TRN	Township	1:4 800
BLM Roads	TRB	Township	1:4 800
Stream Reach, Name, Order	HYD	Township	1:4 800
Gross Vegetation	GVG	Township	1:4 800
Misc Cultural Line Features	MFL	Township	1:4 800
Misc Cultural Point Features	MFP	Township	1:4 800
Geographic Names	GNS	Township	SI
Township Perimeter	PER	Township	SI
PLSS Grid	PLS	Township	SI
BLM Ownership	OWN	Township	SI
Contours, Intermediate	CON	Township	1:4 800
County Boundaries	COB	WODDB	1:500 000
District Boundaries	DOB	WODDB	1:500 000
Water Bodies, Lakes	LAK	WODDB	1:500 000
Transportation Network,Roads	TRN	WODDB	1:500 000
Master Units	MUB	WODDB	1:500 000
Streams	HYD	WODDB	1:500 000
BIG GAME:			
Distribution of Elk	ELK	QUAD	1:100 000
Elk Winter Range	EWR	QUAD	1:100 000
Deer Winter Range	DWR	QUAD	1:100 000
ODFW Management Units	OMB	QUAD	1:100 000
CULTURAL:			
Known Areas, 40 Acre PLS Grid	CRM	TOWNSHIP	1:12 000 36
FISH:			
Fish Habitat	FSH	TOWNSHIP	1:12 000
Fish Management	FSM	TOWNSHIP	1:12 000
FIRE MANAGEMENT:			
Air Quality Designations	AQD	QUAD	1:100 000
FORESTRY:			
Operations Inventory	FIO	TOWNSHIP	1:12 000
TPCC	TPC	TOWNSHIP	1:12 000
5-Point Inventory Plots	5PT	TOWNSHIP	1:12 000
BLM Forestry Breeding Units	FBU	QUAD	1:100 000
Tree Improvement Coop Units	TIU	QUAD	1:100 000
LANDS:			
County Boundaries	COB	TOWNSHIP	1:12 000
District and Resource Areas	DOB	TOWNSHIP	1:12 000
Master / Planning Unit	MUB	TOWNSHIP	1:12 000
Land Tenure Zones	LTZ	QUAD	1:100 000
Utility Right-of-Way	URW	TOWNSHIP	1:12 000
Communication Sites	GCS	TOWNSHIP	SI
Land Withdrawals	WDL	TOWNSHIP	1:12 000
Land Use Leases	LSE	TOWNSHIP	1:12 000
County Zoning	CTZ	QUAD	1:100 00
Congressional Districts	CGD	WODDB	1:500 000

DESCRIPTION	MAP NAME	UNIT OF COVERAGE	INPUT SCALE
MINERALS:			
Geothermal Mineral Potential	GMP	WODDB	1:500 000
Oil & Gas Potential	OGP	WODDB	1:500 000
Coal Mineral Potential	CMP	WODDB	1:500 000
Geology, Formations, Surface	GEO	WODDB	1:500 000
Pot Occur, Locatable Minerals	LMP	QUAD	1:100 000
Mineral Material Sites	MMS	TOWNSHIP	1:12 000
PLANT COMMUNITIES:			
Major Plant Grouping	MPG	QUAD	1:100 000
RECREATION:			
VRM Classes & Scenic Quality	VRM	TOWNSHIP	1:12 000
Recreation Management Areas	REC	TOWNSHIP	1:12 000
SOIL:			
SCS General, Associations	SLS	WODDB	1:500 000
SPOTTED OWL:			
Activity Centers	SOC	TOWNSHIP	1:12 000
Home Range Female	SOF	TOWNSHIP	1:12 000
Home Range Male	SOM	TOWNSHIP	1:12 000
Home Range Pair	SOP	TOWNSHIP	1:12 000
Area Used by Young	SOY	TOWNSHIP	1:12 000
Telemetry Locations	SOT	DISTRICT	SI
T&E PLANTS:			
Site of Sensitive Plants	TEP	TOWNSHIP	1:12 000
Federally Listed	TEF	TOWNSHIP	1:12 000
Federal Candidates	TEC	TOWNSHIP	1:12 000
State Listed	TES	TOWNSHIP	1:12 000
Bureau Sensitive	TEB	TOWNSHIP	1:12 000
TERRESTRIAL:			
Raptor / Heron Nests	RHN	TOWNSHIP	1:12 000
Special Habitat Features	SHF	TOWNSHIP	1:12 000
Priority Animal Species	Pnn	TOWNSHIP	1:12 000
WATERSHED:			
Analytical Watersheds	AWS	QUAD	1:100 000
Municipal/Community Watershed	MWS	QUAD	1:100 000
Weather Stations	WST	WODDB	1:500 000
Precipitation, 2 yr - 24 hr	PPT	WODDB	1:2 000 000
Water Diversions	WDV	TOWNSHIP	1:12 000
Gaging Stations	GST	WODDB	SI
10-YEAR SCENARIO:			
Transition Sale Units	TTS	TOWNSHIP	1:12 000
Transition Roads	TTR	TOWNSHIP	1:12 000
Representative Timber Units	RTU	TOWNSHIP	1:12 000
Representative Roads	RTR	TOWNSHIP	1:12 000
Potential Sale Units	10Y	TOWNSHIP	1:12 000

Note: SI is Scale Independent, features generated from coordinate data.

The attainment of this highly detailed level of data in a very short time frame (from 1985 - 1990) required the formation of a "Toolbox" of hardware, software, and personnel consisting of existing items as well as substantial innovation. An unique mix of minicomputers, microcomputers, smart terminals, video processing, off-the-shelf and in-house software, color electrostatic plotting, project management software, local area network, and a support services contractor have made the project achievable.

The base and thematic layers will be linked via software to currently active relational databases. Eventually, all of the separate databases will be aggregated into one relational database management system (GIS World, 1988). A Prime 9955-II in the Portland office serves as a host to the smaller Primes located at the District Offices as well as the mini Primes in the resource area offices. Access to the primes is through smart graphics terminals based on 386 microcomputers running Graphpoint TGRAF-07 Textronix emulation software. The MOSS (Map Overlay and Statistical System) GIS software, originally developed by the U.S. Fish and Wildlife Service, is the USDI BLM standard system. For the digitizing, AutoCAD was utilized. Wherever necessary, additional software linkages were developed to serve as the bridges between AutoCAD, MOSS, and the relational databases.

GIS AS A STRATEGIC AND TACTICAL FOREST MANAGEMENT PLANNING TOOL

A special team of planning coordinators and resource specialists have identified 183 planning issues that will need to be analyzed in the 1990 RMPs. The vast majority of these issues result in spatially oriented conflicts. Historically, planners have used transparent map overlays and colored pencils as a means of identifying the land use conflicts and attempting to resolve them. With the advent of mini and micro computer technology and the implementation of a GIS natural resource policy conflicts can be more rapidly displayed and computational analyses implemented to discover and evaluate the compromises relevant to natural resource management.

Six "common" alternatives will be addressed in each of the Sustainable Yield Master Units (SYMUs), to provide a consistent set of distinct choices among potential management strategies. Land use decisions are to be broadly implemented under any given alternative. The purpose of alternatives is to identify a range of reasonable combinations of resource uses and management practices that respond to planning issues and provide management direction for all resources.

In the past, large scale-harvest scheduling models are predominately two dimensional in nature; they were used to determine the number of acres to treat, as well as the timing of the treatments. The unanswered question has always been the spatial distribution of the treated stands. This has been an easy question to ignore since most large scale harvest scheduling models; FORPLAN, MAX MILLION, TREES, ... (Davis and Johnson, 1987) have been primarily applied under two situations. First, most large Public policy analyses have utilized 10 year periods with 100's of years in the planning horizon, resulting in very large model formulations with individual stands aggregated in some manner. Spatial issues were ignored so the problem could be solved.

This approach has worked very well while the goal of forest management was primarily concerned with the conversion of vast, fairly homogeneous natural forests, into a managed system. In the second approach, private corporations have formulated models identifying all the individual stands but on a short-term planning horizon. Spatiallity was only incorporated after the harvest scheduling analysis and implicitly not considered in the analytical model. This system worked because the harvest analysis is repeated annually, or more often, allowing for corrections. But to meet the needs of current forest conditions with the increasingly complex institution of public forest planning, a spatially oriented approach is a modern necessity.

STRATEGIC, OR ANTERIOR PLANNING

Another aspect of the planning process is strategic, or the anterior planning problem which refers to calculating the productivity of the forest through manipulating the spatial database (WODDB) and redefining the forest inventory with the relational database (MICRO*STORMS) to determine the forest inventory which will provide the operational inventory for the harvest scheduling (TRIM - Plus) model (Figure 1). The Operational Inventory (OI) in WODDB is linked with the stand characteristics data in MICRO*STORMS. Each OI unit is identified in WODDB as a polygon with a set of attributes. These attributes are stand characteristics which have been loaded from the relational database. As the units change, both databases can be modified. The WODDB GIS provides the mechanism for calculating the acreage for every OI unit, accounting for roads, rivers and other restrictions. These revised acreage estimates will be instrumental in the formulation of the next step, TRIM-Plus harvest scheduling model. The delivery of the spatial data in WODDB is crucial for the estimation of the actual acreage numbers to be used in the resulting harvest scheduling analyses.

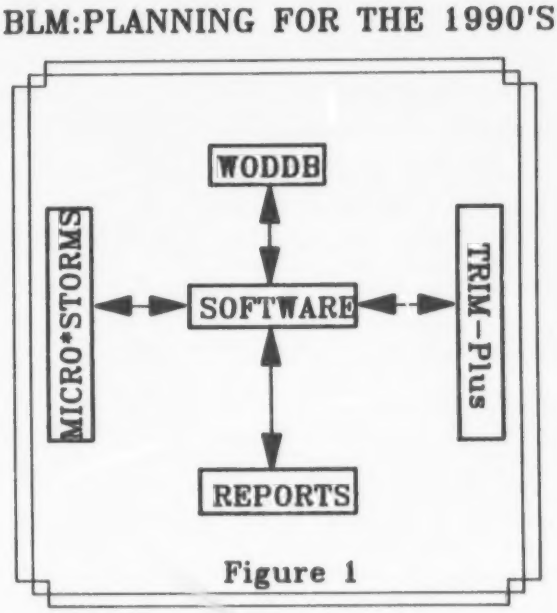


Figure 1

Given the increased accuracy in reporting existing features, the location of special use sites such as an existing or potential recreational site, or the nesting sites of Bald Eagles will be "predetermined". Natural resource professionals will designate special use areas, or sites out-of-the base. Acreage with reforestation problems due to fragile soils, or which are noncommercial due to low productivity or with noncommercial species will be removed from the operational inventory. The OI for each of the alternatives rests on determining whether stands fall under the following criteria recreation sites, sites with Federal Proposed and Candidate, State Listed and/or Bureau Sensitive (animal, reptile, fish or plant) species, Areas of Critical Environmental Concern, Research Natural Areas, Visual Resource Management Zones, Municipal Watersheds, Riparian Management Areas, and Wild, Scenic and Recreation River Corridors. Blocks of old growth timber will also be selected to form habitat corridors throughout the landscape for several of the alternatives. Most of these decision criteria are represented in one or a combination of WODDB themes.

Some of these criteria represent non-spatial factors which may preclude the consideration of a stand from the operational base for any one of the alternatives being studied. However, many of the criteria are spatially oriented. For example, the width of Riparian Management Zones represent buffers along rivers and streams,

while the shape of Visual Resource Management Areas depict a viewshed in a three dimensional space. Additionally, the existence and placement of sites already allocated to other restrictive criteria will influence the locational designation of habitat corridors via selection of appropriately situated old growth stands. The net effect is that the operational inventory will change between alternatives. Acreage variation will occur through the Boolean manipulation of polygon features of the WODDB data with the resulting changes in the operational inventory being determined by the characteristics of individual forest stands as well as their placement.

Once the operational inventory is determined, the resulting age class distribution by productivity class, past stand management regimes and acreage information is formulated for the harvest scheduling model. The model will then determine the non-declining sustained yield which can be expected from each of the individual twelve SYMUs. The harvest scheduling model, TRIM-Plus, Timber Resource Inventory Model Plus Harvest Scheduling Model (Tedder and LaMont, 1988) is a software program designed to model and project timberland inventories under many different management regimes. The model forecasts harvest schedules and in turn provides comprehensive output detailing future inventories, timing of management activities and harvests. Since it can be run on a microcomputer, it is not subject to a per simulation cost, only restricted by run time and manpower limitations. Thus, if the inventory base is altered for any given "what if" question, the harvest scheduling model will often only require revision of the acreage estimates.

TACTICAL, OR POSTERIOR PLANNING

Once a preferred alternative is selected for the 1990's RMPs, the location of future sale units must be determined if the environmental impact is to be calculated for implementation. As with most other large scale harvest scheduling models, the TRIM-Plus model does not consider the actual location of individual harvesting or management activities during the planning horizon. Therefore, it is still necessary to assign these activities to spatially defined locations. Since the RMPs are to be implemented at the Resource Area, harvest volumes need to be re-allocated spatially within SYMUs at that level. For the purpose of conducting the environmental impact analyses, sale unit allocations will be required within analytical watersheds.

The output files from TRIM-Plus does not actually identify the individual stands to be treated in any particular period, however they do provide critical information in allocating the harvest back to the ground. Not only will the output define how much volume is to be harvested in any given period for a SYMU, the volume by age class as well as the general management unit or set of aggregated stands are defined. The aggregation of individual stands is based on the expectation that they all grow similarly. These management units, defined as Basic Resource Units (BRUs) in TRIM-Plus are formulated to reflect the different species, site classes, BLM ownership criteria, as well as management administration designations so as to represent the probable productivity of the inventory. The resulting model formulation and corresponding output presents the analyst with a complete description of the type of stands the model assigned treatments, as well as their timing, in order to maximize the non-declining evenflow objective.

The posterior planning problem then actually represents the tactical planning problem with which most professional foresters are acquainted: "determining which stand to treat and when" in order to meet the projected annual harvest volume goal. With the output from the harvest scheduling model described above, the spatial allocation of sale units may be determined for some sets of stands which meet the spatial, treatment and timing issues of thecombined problem. The problem may or may not be feasible. If the posterior problem is infeasible, then changes must be made in re-defining the initial available operational inventory and a new harvest simulation implemented. If the solution is feasible, then the analysts will need to determine the set of sale units which best meet the overall goals.

In a test township which was initially established in the WODDB for planning and process evaluation, a team of sale planners determined that the selection of stands for any given year's harvest volume goals could be accomplished for that township. For the larger task of applying the cut over an entire SYMU, previous work like that reported by Nelson (1988) indicate that this type of problem could be solved via a Monte Carlo Integer Programming Model. Other heuristic network algorithms may also exist which are applicable. Further study in this topic will occur before this stage in the planning process is completed.

While working with this test township, the analysis by the sales team did recognize a problem with the original formulation of the inventory data in WODDB. Operational inventory units are the primary focus of the database, both in WODDB and in the traditional relational database. However, the planners acknowledged that sale units are normally smaller than the OI units. Therefore they prototyped the procedures necessary for the creation of an entirely new theme which would describe all the potential sale units within the WODDB coverage. The creation of the new database then provides the necessary resolution for the analytical methods for choosing harvest sites as well as relating the harvest of these sites to analytical watersheds for thecomputation of cumulative environmental impacts.

SUMMARY

Currently, software and prototype procedures are under development while the WODDB data is digitized and compiled into the GIS. Project schedules indicate that the necessary components of the WODDB database are to be completed during the summer of 1989 while the initial phase of the comprehensive RMP process should be completed by late fall. Utilization of analytical models for the anterior and posterior evaluation of the alternatives as described in the State Guidance as well as additional "what if?" analyses will continue on the Districts as long as the RMPs progress through the proscribed public involvement process; culminating in final approval and implementation. Once the specific RMP for a SYMU is determined, the WODDB GIS will serve as a focus for plan implementation, monitoring and data collection.

REFERENCES

Davis, Lawrence S. and K. Norman Johnson. 1987. **Forest Management**. McGraw- Hill, Inc. New York, NY. 790pp.

Nelson, John D. 1988. **Integrating Short-Term Spatially Feasible Harvest Plans with Long-Term Harvest Schedules Using Monte-Carlo Integer Programming and Linear Programming**. Unpublished Ph.D. Dissertation. School of Forestry, Oregon State University, Corvallis. 168pp.

Tedder, Philip L. and Richard N. La Mont. 1988. **TRIM-Plus: Timber Resource Inventory Model Plus Harvest Scheduling Software Manual**, Resource Economics International Incorp., Corvallis, OR. 129pp.

USDI, Bureau of Land Management. 1984. **Timber Management for the 1980's.** Oregon State Office, Portland, Oregon. 24pp.

USDI, Bureau of Land Management. 1988. **Planning for the Public Lands in Western Oregon: Proposed State Director Guidance.** Oregon State Office, BLM-OR-GI-88-8-1792, Portland, Oregon. 116pp.

Wright, Robert A., and Don Pearson. **1988. The WODDB "Toolbox".** Oregon State Office, Bureau of Land Management, Portland, Oregon. pp. 840-842.

Disclaimer

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not constitute or imply its endorsement by the United States Government or the Department of Interior, Bureau of Land Management.

REFINEMENT OF A MODEL USED TO INTEGRATE THE MANAGEMENT OF DEER AND FORESTS

Marvin A. Eng
Ministry of Environment, Nanaimo, B.C.

R. Scott McNay
University of British Columbia, Vancouver, B.C.

Rick E. Page
Ministry of Forests, Victoria, B.C.

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT OF POSTER

Integrating the management of forests and deer on the lower coast of British Columbia has had a varied history and much research. Most of the effort to date has been focused at the retention or improvement of winter habitat on a scale equivalent to a forest stand (20 -200 ha). Using a Geographic Information System (GIS) and expert system software, we are developing a management tool that would allow a planner or manager to assess stand level management actions in a watershed or regional context. The original form of the management tool is described. We then present two subsequent steps taken to improve the tool. The expert system-based management decision model was evaluated by comparing the responses of professionals with knowledge of deer and forest management on B.C.'s lower coast. The GIS winter habitat suitability model was assessed by comparing weekly locations of deer fitted with radio-collars with model predictions. The deer location data was obtained during a year of moderate winter severity, so deer were not heavily constrained when choosing habitat.

Preliminary results indicate that the management decision model substantially agreed with expert opinion. However, the aspects of the model related to predation and winter severity need further clarification. The predictions of the GIS habitat suitability model and observed deer habitat selection were very similar. We suggest that a better test would be a comparison of model predictions and deer habitat choices made during a severe winter when deer will not be able to survive in sub-optimal habitat. Therefore, better data are necessary for a strong test.

A TECHNICAL AND OPERATIONAL COMPARISON OF GEOGRAPHIC INFORMATION SYSTEMS AS APPLIED TO THE CANADIAN FOREST INDUSTRY

Eric (Alex) Ferguson, B.Sc.F.

Reid, Collins and Associates
1550 - 401 West Georgia Street
Vancouver,
British Columbia
V6B 5A1

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

In December, 1988 - January, 1989, Reid, Collins and Associates conducted a technical and operational comparison of Geographic Information Systems as applied to the Canadian forest industry. Of 84 surveys sent, 53 were returned complete; however only 36 were returned in time for presentation in this report. Where possible, respondents were contacted in order to clarify feature definitions. Trends and directions in this technology were identified through vendor and user interviews. Few vendors are actively advancing the science and technology of GIS, preferring to follow industry leaders. Product support and longevity is questionable for many vendors, as pursuit of increasing the installed base supercedes user support efforts. Very few vendors are directing research and development efforts to those concerns commonly identified by the GIS community. The survey results are valuable to potential users of the technology, as a single step in the purchase decision making process, as well as current users who are concerned with where the technology is heading.

PROJECT DESCRIPTION

In late 1988, Reid, Collins and Associates undertook a major survey of Geographic Information Systems available to the Canadian forest industry. At first, only those products which were directly marketed to Canada were considered, but with advent of freer trade with the United States, the survey was expanded to encompass that market segment as well.

In an initial search for vendors, over a hundred were identified. A judicious "thinning" process reduced this list to eighty-four potential respondents. To increase the response rate, many of these vendors were contacted by phone prior to sending the survey form.

One aspect of this project involved identifying trends and directions in this technology. Numerous follow-up contacts were made with certain vendors, in order to determine their thoughts and concerns on this topic. A few user groups were interviewed (with most input obtained from our own clients' experiences) to help identify issues which most concerned them.

Of the eighty-four surveys sent out, thirty-six were returned with an enthusiasm expected from groups servicing the public. Many of these responses included detailed product literature and technical specifications. Six of these were from educational or research oriented institutions. Of the non-respondents, twelve were no longer in operation or had relocated to unspecified locations; eight were from universities where such research initiatives are typically transferred among disciplines making contact difficult; nine chose not to respond for a variety of reasons: the most common being a perception of product unsuitability for forestry/natural resource applications. There was one respondent who declined to allow publication of product information in this report. One other respondent agreed to be removed from compilation when further contact established that the product was not a true GIS.

Seventeen vendors did not respond in time for inclusion into this report, but their response is most appreciated and is used extensively in the identification of trends and directions in this technology.

It is important to realize that this survey does not represent a comprehensive benchmark of vendor product offerings. Rather, the results were compiled such that a potential user can select a number of systems which meet his or her unique requirements, and then follow a comprehensive methodology for narrowing the field. Since GIS technology is constantly evolving, readers should be aware that significant changes will undoubtedly occur to the stated list of features any one vendor may claim to have. This survey should be used only as a single preliminary step in the selection of GIS products.

This project has been developed under the guidance of Art Shortreid, Forestry Canada and Michael Heit, Forestry Canada. Funding has been provided through the Canada - British Columbia Forest Resource Development Agreement (1985-1990). The material was researched, written, and produced by Reid, Collins and Associates.

EDUCATIONAL AND GEOGRAPHICAL INFORMATION SYSTEMS

"The real problem is not whether machines think, but whether men do". (BF Skinner)

Charles Goodbrand

Program Head
Spatial Information Systems
British Columbia Institute of Technology
Burnaby
British Columbia
V5G 3H2

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

An often overlooked aspect of the acquisition of a GIS is the cost of training of personnel. This paper looks at some of the hidden costs, and will review the types of training that must take place if an organization is to absorb a GIS successfully .

INTRODUCTION

When we think of computerizing the forest inventory problem, we plan for hardware and software acquisitions and allocate budget dollars; when we examine this acquisition and implementation process, we often overlook our most important resource, the expert personnel that will make the project work. I want to examine the role of education with respect to GIS. To do so, I will have a quick look at where GIS is today, what every manager needs to know about GIS, who needs to be educated/trained for the corporate goal of GIS to be attained and how education needs to be structured to help achieve that goal.

WHERE WE ARE

The "state of the art" in GIS today has much in common with the "state of the art" in transportation in the early 1900s. At that time horses and bicycles were the predominate modes of transport: the car had been invented, but was treated as a "horseless" carriage or a rich man's motorized bicycle. The development of an infrastructure (paved surfaces, gas stations) tailored to suit a "novelty" must have seemed ridiculous and certainly expensive. Functional specialization differentiating between cars, trucks, tractors was accomplished by putting a larger box on the back of the chassis. Many years would pass before it was recognized that the rules of the road needed to change to suit this faster, more particular horse. Every person was his own mechanic; each owner a mechanical "hacker".

The infrastructure for GIS- the highway system consists of an available, common set of positional data (TRIM, CGIS, CANSIS, etc.); a common feature encoding schema; data exchange standards (National Standards for the Exchange of Digital Topographic Data); and a suitable standard user view of a GIS - brake and gas positions. This infrastructure, and it is expensive, is under development now. Educational institutes continue to play a key role in the Research & Development efforts required to advance these developments; an overlooked role of education is to transfer today's technology into the workplace.

The "mechanics" and "drivers", as opposed to designers, of GIS today are that unofficial, applications oriented (foresters) group of "hackers" who have been playing with the corporate GIS for the last few years. This group has tended to pick up their expertise on the job, often after hours; as a result, many of the gains in operational expertise are private islands within the corporation.

Managers want to treat a GIS as "just another tool": a calculator, or a drafting board, a filing cabinet - anything except a computer! We want the computer to give us the feel of existing "tools", we want to stay with our horse; we do not want to change the rules of the road, we just want everything to be easier and faster.

Today we tolerate a few "hackers" because these few will eventually help us off the horse. When that day comes, "geocoded relational database" will roll off your tongue as easily as "carburetor" does today but, that will take a concerted effort by you, your corporation and the educational institutes. We will have to incorporate some of what the "hacker" is learning into our management attitudes.

WHAT EVERY MANAGER NEEDS TO KNOW ABOUT GIS

GIS is introduced to increase the efficiency of decision making and planning: the measures of efficiency are time and dollars. GIS is also introduced to improve the quality of decision making and planning: the measures of quality are "intangibles" accuracy of prediction, reduction in permit approval delays, etc.- indirectly measurable in time and dollars. When acquiring GIS the manager must use the classic formula:

$BENEFITS - $COSTS = + $, happiness all round
$BENEFITS - $COSTS = - $, misery.

In order to apply the formula the manager must be able to do two things:

(I) precisely formulate potential efficiencies and quality improvements the benefits of GIS;
(II) precisely formulate what costs will be incurred to achieve these benefits.

A quick example to illustrate:

How many hectares of license land consists of stands with areas greater than 1/4 hectare composed of at least 25% fir on slopes less than 10%, within 100 meters of an existing access road?

(I)	Times question asked	3 per annum of each lease 10 leases
	cost per time	$ 1,000
	potential benefit	$30,000 per annum

The manager, having used all the traditional techniques, is expert at describing those techniques and calculating their costs. The manager, whether a professional forester or not, could look around the office and total staff costs. Accurately analyzing benefits of bringing in a computer, GIS, will cause immediate problems for the manager who is not familiar with computers and computer acquisitions. The manager must:

(II)
- (a) select correct software solution
- (b) select correct hardware solution
- (c) select correct network solution
- (d) produce implementation plan for hardware
  - (i) establish hardware and network configuation
  - (ii) establish day to day operational procedures
- (e) produce implementation plan for users
  - (i) plan for data collection and verification
  - (ii) plan for multiple data source overlays
  - (iii) select and train users
  - (iv) plan for local optimizations

The immediate problem with the costs side is that every step requires some computer expertise. The manager can now make a choice:

(a) forget GIS, it's too difficult
(b) call in the Computer Resources Department
(c) call in a consultant.

Without any expertise at all any of these decisions is poor: the corporation may be missing the boat by passing on GIS; Computer Resources groups are usually experts on Business System (MIS), but usually lack the forester's knowledge of the operational problems a great computer/poor solution may result; no corporation should place itself entirely in the hands of a consultant. Not only does the manager need to understand computers to acquire the right GIS, but the manager needs expertise in computers to make GIS work.

In the ideal forestry department, a fourth way would have been available:

(d) call the GIS facilitator within the forestry department.

The facilitator today would be the "hacker" who has quietly been exploring the ins and outs of computers privately, but who is a forestry expert as well. As a trusted member of the manager's department the facilitator will best assist the manager in dealing with technical computer experts.

WHO NEEDS TO BE EDUCATED?

If we were introducing tree harvesters into the company for the first time, I would put together a training package along the following lines:

1) training for users of TH (AKA operators);
2) training for TH support staff (AKA mechanics);
3) courses for successful management of TH (budgeting, scheduling, constraints).

We might argue about the dollars and cents of training costs; we might argue about who will bear the cost- the individual, the corporation, or government we wouldn't argue about whether training is required!

This is not the case when I speak on Education and GIS!

With GIS, I usually confront an audience who believes GIS is or should be a tool which:

1) is so transparently easy to use that NO new skills are required to become expert;
2) is so well designed that NO support staff are required to keep it tuned for the local applications;
3) is so similar to other operations within the corporation that NO new management skills are required!

Applying the same logic to THs I would like to introduce a new device, the Personal Tree Harvester (PTH). This device is perfect in the sense that it eliminates all of the those overhead line items. It is so easy to use that no training is required for users, support staff, or managers. Furthermore it will be a productive tool from day one!

The type of training required for each of these groups is different. I am not suggesting that chief foresters become computer programmers! I am suggesting that we cannot rely on "hackers", who ultimately make these GIS systems work, spontaneously springing up from within the forestry group, we must plan for their existence. I would also argue that "operators" of GIS are not a separate species from foresters, in the same way that engineers and slide rule users were not two different species.

HOW TO STRUCTURE THE EDUCATION

Managers

Managers need to be educated before the big decisions on GIS are made. Curriculum would include:

(a) explanations of the technical terminology to demystify the technology;
(b) identification of hardware capabilities and costs would assist the manager in selecting the right size of solution;
(c) for the same reason, definition of software types and capabilities
(d) network types and capabilities.

Managers need education after the big decision on GIS is made. Curriculum should include:

(a) new trends in GIS;
(b) better management of the existing technology;
(c) technical management of computers.

Management training should be structured as small, short seminars that focus on actual cases led by experienced GIS managers.

Facilitators

A facilitator is an expert in the engineering discipline of your department forestry, survey, geography, geology, etc. who has developed expertise in computers programming, databases, networks, hardware. The facilitator can deal with your engineering problems and computer problems.

The facilitator can recognize, recommend and implement local optimizations to your GIS. The facilitator can develop the training plan for your group. The facilitator can monitor the quality of data being produced by the department's data entry personnel. The facilitator can arrange for the transfer of outside data and provide for the utilities to incorporate the external data into the local GIS system. The facilitator can act as the liaison between your group and the Computer Resources computer experts or with the outside GIS consultant. It is my belief the successful development of facilitators within each user department is what determines the success or failure of your GIS. The facilitator can warn the manager of pitfalls and assist in steering the manager to success.

If the department has self-motivated "hackers" already in place, they should be encouraged and trained more deeply.

One and two week long technical courses, Continuing Education programs and technical seminars should be encouraged in specific technical topics from both fields of expertise.

If the department does not yet have facilitators, the manager should budget for one. Educational institutes are providing a great deal of leadership in this area, for example, BCIT provides a 9 month post-diploma program in Spatial Information Systems.

Users

In GIS, users are the easiest group to train. Since your users already have expertise, they need only be trained in operation of the computer. The facilitator can make local modifications to most systems so that computer expertise is minimized. Nonetheless, training in GIS related skills should be encouraged.

CONCLUSION

In summary, GIS provides us with great and useful technological advances. The manager of the GIS system within the forestry department will best achieve the promise of these benefits by having a well trained and motivated staff.

GIS - THE SASKATCHEWAN EXPERIENCE

Fern Gruszka

Head, Systems and Geographic Information Systems
Forestry Branch
800 Central Avenue
Prince Albert, Saskatchewan

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Saskatchewan has maintained its forest inventory in a digital grid-cell format since 1979. This has proven to be a versatile and effective data management technique. In 1986 a vector based GIS was acquired and a process was undertaken to convert the grid cell data into a vector, polygon coverage. This paper describes the conversion process, the problems encountered and demonstrates the graphic evidence of a successful conversion. A review of other agencies utilizing the grid-cell data in its original or converted form is presented as a demonstration of its use in integrated resource planning in Saskatchewan.

INTRODUCTION

Ladies and gentlemen, in my presentation today I will provide you with an update of Geographic Information Systems (GIS) usage in Forestry Branch of Saskatchewan Parks, Recreation and Culture and also share with you some of the highs and lows we have experienced during the last year as we embarked on a full implementation schedule.

I must first of all emphasize that, based on our long term objectives, we are far from completely operational and indeed have many projects ahead of us that will challenge our ingenuity for a number of years.

Many agencies have experienced the joys and pains of GIS implementation over the last few years, and many have recounted their experiences at forums such as this; therefore I will not dwell on this area too long. My main focus will be to describe to you a unique data conversion project, which has given Saskatchewan virtually complete GIS coverage of the forest theme, within months of start-up.

I will also describe to you a number of projects which we have undertaken in our efforts to build a provincial integrated resource database, some of the agencies with whom we have cooperated in access and use of our GIS coverages and lastly, show you a number of graphic products which our small implementation team has successfully developed from the converted grid cell data.

BACKGROUND

For those of you unfamiliar with the scope of Saskatchewan forestry I will provide you with some basic statistics:

Commercial Forest Zone

- approximately 13 million ha (6.5 million productive) Northern Reconnaissance Zone
- approximately 17 million ha (4 million accessible) Forestry Operations
- 6 large forest companies engaged in the harvest and manufacture of wood products (5 under control of Forest Management Licence Agreements).

Economic Impact

- Forestry represents 16% of Saskatchewan's manufacturing sector.
- Export sales of wood products exceed $300 million annually.
- The forest industry contributes $140 million annually in Value Added to the provincial economy.
- Provides 7000+ person-years of direct and indirect employment.

Saskatchewan's involvement with GIS technology started in the mid-seventies. The following series of events describe the progression to current levels of usage:

1976-77 : Saskatchewan Forestry Division embarked on a major revision in its Forest Inventory methodology. This included use of Metric units of measurement instead of Imperial, adoption of a significantly more detailed stand classification system, adoption of a metric mapping scale of 1:12 500and adoption of the Universal Transverse Mercator (UTM) projection for its base mapping. With such massive changes in the data capture and retention process and a new series of maps to be produced, initial investigations were undertaken into the availability of automated systems which would incorporate spatial referencing and map production capabilities. Much of the funding for this inventory revision and GIS investigation came from the Department of Regional Economic Expansion (DREE).

1978-79 : By 1978, in excess of 200 base maps had been manually produced using the new inventory specifications. Demand for access to the new Inventory was very high, both internally and from the forest industry. It became necessary to undertake immediate development of internal automated systems for the provision of basic area-volume reporting. It is important to note that the provincial forest inventory was at that time the primary source of data for the largest forest company in Saskatchewan (Prince Albert Pulp Company - PAPCO). In cooperation with two government agencies, SASKCOMP and the Systems Division, the necessary software was developed and appropriate hardware was acquired to capture all newly drafted maps in a grid-cell format. This system has been commonly referred to as Computer Assisted Dot Counting (CADC).

1979-80 : The first intensive evaluation of GIS technology and review of available systems were undertaken. Tomlinson and Associates - Consulting Geographers, were contracted to assist with this work. A well documented and published analysis of Saskatchewan's needs resulted from this work. A number of GIS systems were benchmarked and subsequent evaluations revealed less than spectacular results. It was the consultant's view that, in 1980, no one GIS fully met the needs of Saskatchewan for processing of geo-

referenced data. A number of vendors were prepared to develop the necessary capabilities at Saskatchewan's expense but this was not seen as a cost-effective option. The consultant recommended that Saskatchewan wait a number of years and closely monitor developments in software. A number of other recommendations were made; one was to continue with map data capture on our in-house, grid-cell system and, if desirable, purchase grid plotting software. However, plotting software was in fact never purchased.

1981-82 : Saskatchewan entered into a technology transfer agreement with the Lands Directorate of the Federal Department of Energy Mines and Resources (EMR). This project brought an EMR consultant to Prince Albert to assess the feasibility of utilizing the Canada Land Data System (CLDS) for GIS work in Prince Albert. The project was based on a proposal to convert all grid-cell maps already loaded (in excess of 800 by this time) to CLDS format and to capture remaining maps via a scanning process in Ottawa. If successful, the CLDS software would ultimately execute on an I.B.M. mainframe installation in Saskatoon. Conversion software for the grid-cell data was developed by CLDS and a number of maps were processed and plotted for demonstration purposes. An extensive Production Test was undertaken which saw the scanning and loading of 114 UTM maps for a full operational test. Themes not previously processed as part of the Saskatchewan forest inventory were incorporated in this production test (e.g. Silviculture treatment areas, fire hazard ratings, etc.).

A number of problems related to the processing of very large databases, the logistics of map composition and map scanning in Ottawa, as well as operational costs, made the full adoption of this proposal impractical. The final project recommendation was for continued maintenance and enhancement of the CADC database and production of generalized plots as necessary, using the customized CLDS software already developed. More detailed mapping, overlays, specialized analyses, etc. were to be accommodated by CLDS in Ottawa on a contractual basis. At no time was it considered economically viable to develop in-house graphics capability.

1984-86 : The last, and ultimately successful, attempt at GIS acquisition was initiated in 1984 as a project under the current Federal Resource Development Agreement. By 1984, GIS technology was well established and in extensive use throughout the forest industry. Such factors as improved data handling techniques, development of powerful Data Base Management Systems, the availability of greatly improved, miniaturized and cost-effective hardware as well as enhanced computing and storage capabilities made this technology extremely powerful.

The approach taken by Saskatchewan in its acquisition process was again to contract Tomlinson and Associates, for the purposes of assessing and documenting the needs of Forestry Branch and preparing a Request for Proposals document.

During this review full consideration was given to other resource Branches and a strong emphasis was placed upon long-term use of GIS as a tool for the integrated management of all natural resources within the province.

Sixty-four products were identified for GIS development. They included maps and reports which were being produced manually as well as desirable products which were virtually impossible to produce manually in a timely or cost effective manner. The list of 64 was ultimately reduced to 34 (Essential and High Priority) products which could be reasonably implemented over a five-year period.

By 1984 approximately 80% of the maps in the Commercial Forest Zone (1200+) were available in digital form on the CADC. With such extensive coverage and the large investment in this geo-referenced database, it became a primary requirement of GIS acquisition that the system be capable of processing the CADC data, either directly or through a conversion process. More than 25% of the products to be developed were based on availability of full forest coverage quite early in the implementation process.

In April 1986 Tomlinson and Associates produced a Request For Proposals document. Following a lengthy justification process, approval was received to proceed with acquisition. In the fall of 1986, benchmarking of systems was completed, and in early 1987 a decision was made to acquire an ESRI ARC/INFO system.

PILOT STUDY

Since delivery of equipment in March 1987, the GIS implementation team has undertaken a number of projects. The first and most significant effort was the completion of a Pilot Project. The scope of this project was perhaps more ambitious than necessary and extended over a period of six months from initiation to publication of the Pilot Evaluation Report. However, much valuable training took place during this period of time and a number of auxiliary projects, not directly related to the Pilot, were undertaken simultaneously.

The Pilot study included nine prototype databases and products, located in a portion of the Commercial Forest known as the Fort a la Corne. This is an area of 25 UTM map sheets (250 000 ha) with a diverse ecological fabric and multiple land use. The products and databases developed included:

a) a forest cover database from converted grid-cell data
b) a planning map (scale 1:100 000) of Mature Growth Types, with full topological background and an area summary report
c) a planning map of Immature Growth Types
d) a Critical Wildlife Habitat map
e) a hydrology and transportation network map
f) a map of productive forest lands with unknown stocking
g) a database design for silviculture treatment areas
h) a forest cover database of 12 vector digitized maps
i) a composite forest inventory maintenance map (1:12 500) from vector data

In addition to developing prototype products, the GIS implementation team assessed the potential of utilizing the 1:50 000 NTS digital series, incorporation of digital Township Survey control points, optimization techniques in the conversion of CADC data, etc. A complete review of staff utilization, data preparation and loading requirements, demands on GIS equipment, etc. was undertaken. The experiences of the Pilot project were fully evaluated and throughout projections revised accordingly. Unlike projections documented prior to system acquisition, the new figures were based on the capabilities of our own staff and our own operating environment.

It is worthy of mention that one of the strongest recommendations of the Pilot Evaluation Report was the need for additional programmer-analyst resources if any of the applications outside Forestry Branch were to be accommodated within the first three years of operation. We are still working on this.

GRID CELL DATABASE

Let me now describe to you some of the characteristics of our grid cell database, which has given us a valuable head start in establishing a GIS forest coverage.

Each UTM map sheet loaded on the CADC system is processed as follows:

1. A dot grid is overlaid on the mylar of a manually drafted map and a paper copy is produced. Each UTM map sheet covers 10 000 ha (10 X 10 km.). The dot grid used is 160 X 160 dots, producing the equivalent of 25 600 grid-cells, each representing (10 000 ha / 25,600) 0.390625 hectares (approximately one acre).

2. The paper map is placed on a digitizing table and, using a pen cursor, the dots associated with each stand are digitized along with the stand number. Dots associated with non-productive areas are captured and attributed to one of 23 non-productive categories (i.e. water, treed muskeg, treed rock, etc.). The software driving the digitizing process permits entry of strings and blocks of dots to speed up the entry process when possible. All 25 600 dots on a map must be digitized.

3. On a second copy of the map, all stands are manually checked and enumerated by transcribing the stand number and attributes to a coding sheet. Only productive forested and productive non-forested stands are uniquely numbered and coded in this fashion. Non-productive areas are identified only through the digitizing process. Any additional information annotated on the map, but not falling into the standard attribute string, is coded as a COMMENT for the particular stand. The coding sheets are then keyed at a data entry stations, completely independently of the map entry process at the digitizer.

4. The digitized data and the attribute data (with COMMENTS) are transmitted to a remote IBM mainframe installation.

5. A series of COBOL programs are then executed to edit attributes, reconcile grid-cell and attribute data and ultimately reformat the map information for adding to a Master CADC database. The database simply consists of:

   - a map COORDINATE file on which the geographic position of each stand is retained by virtue of its position on a fixed format file (sequential, tape resident)
   - an ATTRIBUTE file on which each map and stand is recorded, along with all attributes and a tally of dots associated with each stand
   - a COMMENT file, consisting only of records for stands which had extraordinary notations

6. Whole maps are added to this database in a sequential order.

7. Map updates are accommodated by the replacement of whole square kilometres only. This allows some measure of control in the update process.

8. Area and volume inquiries are made against a series of provincial Stand and Stock tables and a summarized version of the ATTRIBUTE file, on which the stand area is retained. Use of the full ATTRIBUTE file for frequent retrievals proved to be very impractical and was replaced by a summarized version very early in the implementation process.

9. A second digitizing procedure is available for delineating portions of UTM maps. This is used extensively for reporting of depletions, for analysis of area and volume withdrawals resulting from proposed land use changes (parks, road allowances, Native land entitlements) etc.

A sizeable repertoire of software has been developed during the last ten years to utilize the CADC data. In 1988 1,600 Commercial Forest maps were loaded on this system and fully accessible. Harvest volume schedules and Long Run Sustainable Yield calculations are fully automated utilizing this data. Cutting plans, analysis of disease infestations, proposed silviculture treatment areas, etc., that require access to individual stands are also accommodated. Although development of comparable systems on the GIS is of first priority, it will be a number of years before these are fully replaced. Until that time, our foresters and resource managers will continue to use grid-cell based software for analysis, monitoring and long-term planning functions.

GRID CELL CONVERSION

How did we convert this data and what problems did we encounter ?

Our first attempt at this task was during the Pilot Project. We were indeed successful, as was a previous, four map conversion during the benchmark process. Our real challenge however, was, not simply a map by map conversion, but development of a structure for map processing which would allow for efficient map updating and access in the future, a structure which would allow for a constantly changing mix of converted grid-cell and vector-entered maps, and one which would respond quickly to frequent area and volume inquiries.

To accommodate the large number of (1600+) files, a LIBRARY structure was adopted which grouped maps into strips utilizing the UTM Northing value as an access key. Our current disk capacity allows for on-line storage of approximately 10 strips (300-350 maps), the remainder residing on tape. More on-line storage is being acquired, but under our current operating environment this has proven to be a very practical structure. Converted maps, and ultimately vector-entered maps, are backed off to tape in lots of three strips. The functionality of this approach has yet to be fully tested and will no doubt be supplemented in the future by user defined areas requiring frequent access. Although polygon coverages are managed in this way, a complete attribute file, including polygon areas, is maintained on-line at all times.

The physical migration of grid-cell data was achieved by downloading COORDINATE and ATTRIBUTE files to tape in ASCII format from the IBM mainframe to the PRIME installation in Prince Albert. The attribute data was partitioned into individual files based on the map identification. The COORDINATE data was also partitioned and then vectorized by:

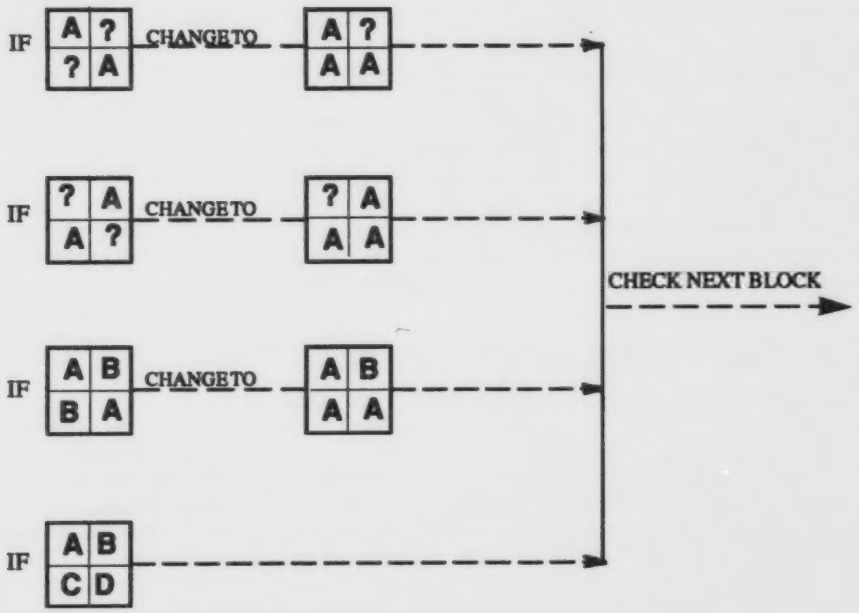
a) converting each grid-cell map into a Single Variable File (SVF) in the appropriate file space, and
b) executing the GRIDPOLY command of ARC/INFO against the SVF, thereby creating individual polygon coverages with stand number as the polygon id.

One of the principal by-products of the vectorization process, and one that had been anticipated, was the creation of many more polygons than stands present on the original grid-cell files. This was viewed as a potential source of inefficiency, unnecessarily increasing processing times in the future. Two causes of this increase were identified:

- aggregation of non-productive areas into individual polygons (grid-cell files treated non-productive areas as discontinuous polygons, maximum 23 types on each map)
- partitioning into multiple polygons of stands which had numerous single cell appendages or which extended diagonally

An acceptable solution to this problem was found and applied during the conversion process. Grid-cell files were individually preprocessed prior to generating SVF files. The preprocessing included:

- dividing each grid-cell into four
- examining each block of four cells and comparing stand numbers in overlapping swathes across the entire map
- for each four cell group the following stand number transformation is applied:



Using this preprocessing algorithm had a significant effect in reducing the number of polygons generated. A typical test map showed the following counts:

Number of stands on Grid Cell files	832
Number of polygons without preprocessing	1923
Number of polygons with preprocessing	1340

This approach had the effect of redistributing some of the area associated with each polygon. An evaluation of the redistribution, by Growth Type, is summarized in the table below.

Area Summary (ha)		
Growth Type	Preprocessed	Not Preprocessed
Immature GT	6118.46 ha	6120.31 ha
Mature BSGT	324.12 ha	323.44 ha
Mature HWGT	140.10 ha	140.47 ha
Mature JPGT	937.89 ha	937.11 ha
Mature PAGT	36.13 ha	3.33 h
Mature SPGT	0.00 ha	0.00 ha
Mature WSGT	26.37 ha	26.17 ha
Not Defined	0.00 ha	0.00 ha
Not Typed	0.00 ha	0.00 ha
Other NP	629.59 ha	627.73 ha
NF/Not Selected	[illegible] ha	494.92 ha
Water	[illegible] ha	28.52 ha
	10000.00 ha	10000.00 ha

Based on the resolution of our grid-cell data (approximately 0.4 ha) and the known error rate within the data-base of approximately 2% (determined from several extensive manual studies), the redistribution of area resulting from the preprocessing was not seen as significant. A decision was taken to preprocess all grid-cell maps prior to conversion.

A second problem successfully overcome during the conversion was the positioning and fitting of converted grid-cell maps into generated file spaces along the two UTM Zone boundaries which traverse Saskatchewan. Grid maps were all retained for full 10 000 hectare coverages, with portions of maps falling outside zone boundaries classified as such.

The file space which was to store converted grid-cell maps was generated on the GIS as a geographically referenced grid. Zone boundaries were generated separately as square lines of specific degrees of longitude. These were then projected to the UTM format. Additional vertices were added at each quarter degree of latitude to maintain integrity with Zone boundaries available to us from a digitized source (a series of NTS 1:50 000 maps).

Maps in the generated UTM grid, which fell along the Zone boundary, were geographically corrected by CLIPing them individually against the Zone boundary coverage.

Converted grid-cell maps were made to fit into these files by processing them in a similar fashion. All polygons classified as 'Out-of-Zone' were first of all eliminated. Next, the CLIP operation was applied to these maps as well. Numerous polygons along the CLIP edge were left open or without a label or with duplicate labels or unclassified. Many of these problems were corrected by EXTENDing arcs to the clipped map edge. The remaining label problems and missing classifications were manually corrected. A complete and topologically clean coverage was ultimately generated for all converted maps.

To facilitate selection of maps and attributes for product generation the LIBRARIAN software of ARC/INFO has been utilized. This has necessitated the aggregation of all attribute data into one large file. Speed of access has been greatly improved by normalization of our attribute file into 7 long, narrow files instead of a single wide attribute table. We will no doubt continue to improve our storage and access techniques as we become more familiar with the software at our disposal.

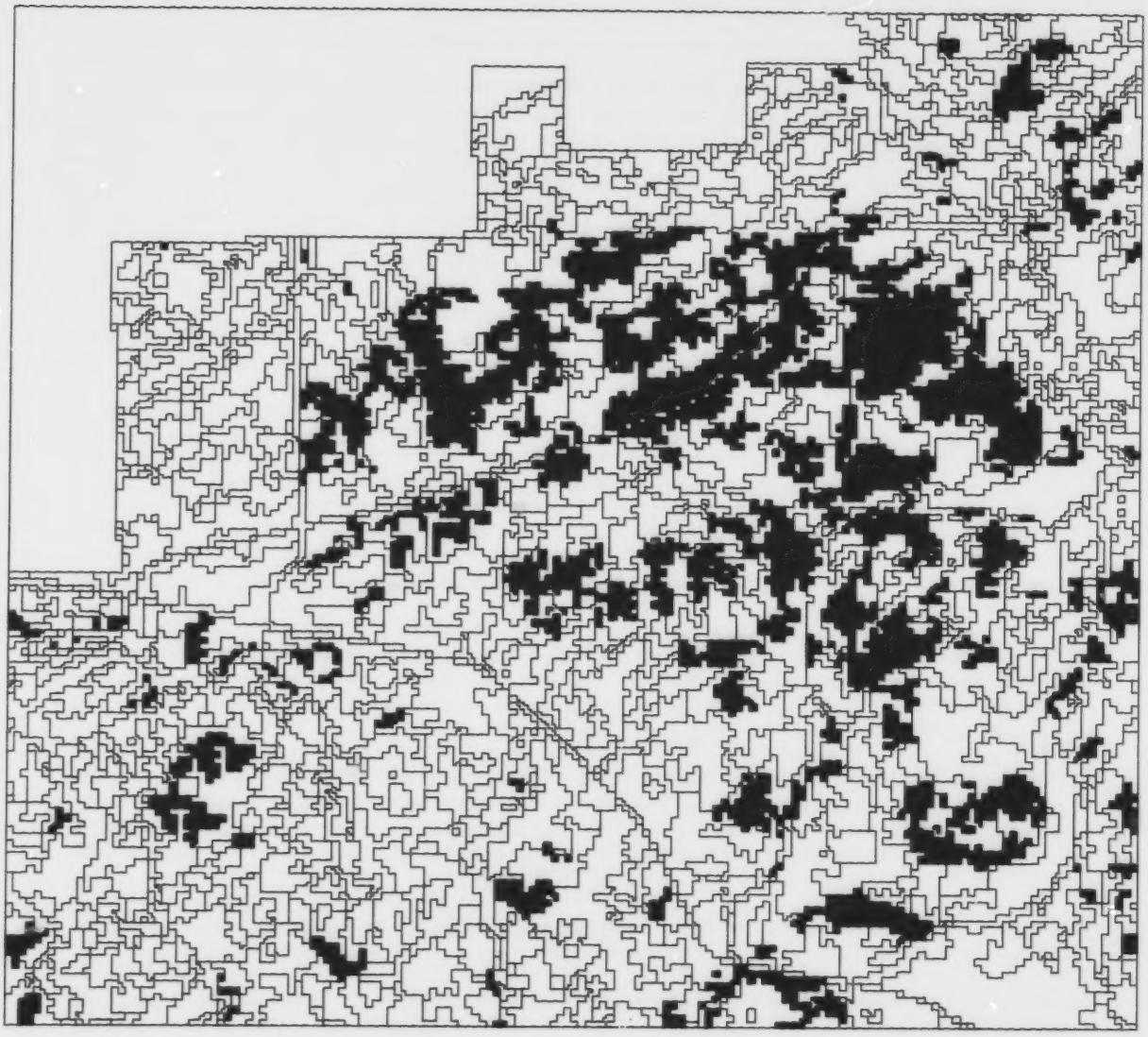


FIGURE 1 : A converted grid-cell map with selected polygons (NSR lands) shaded. Scale 1:12,500.

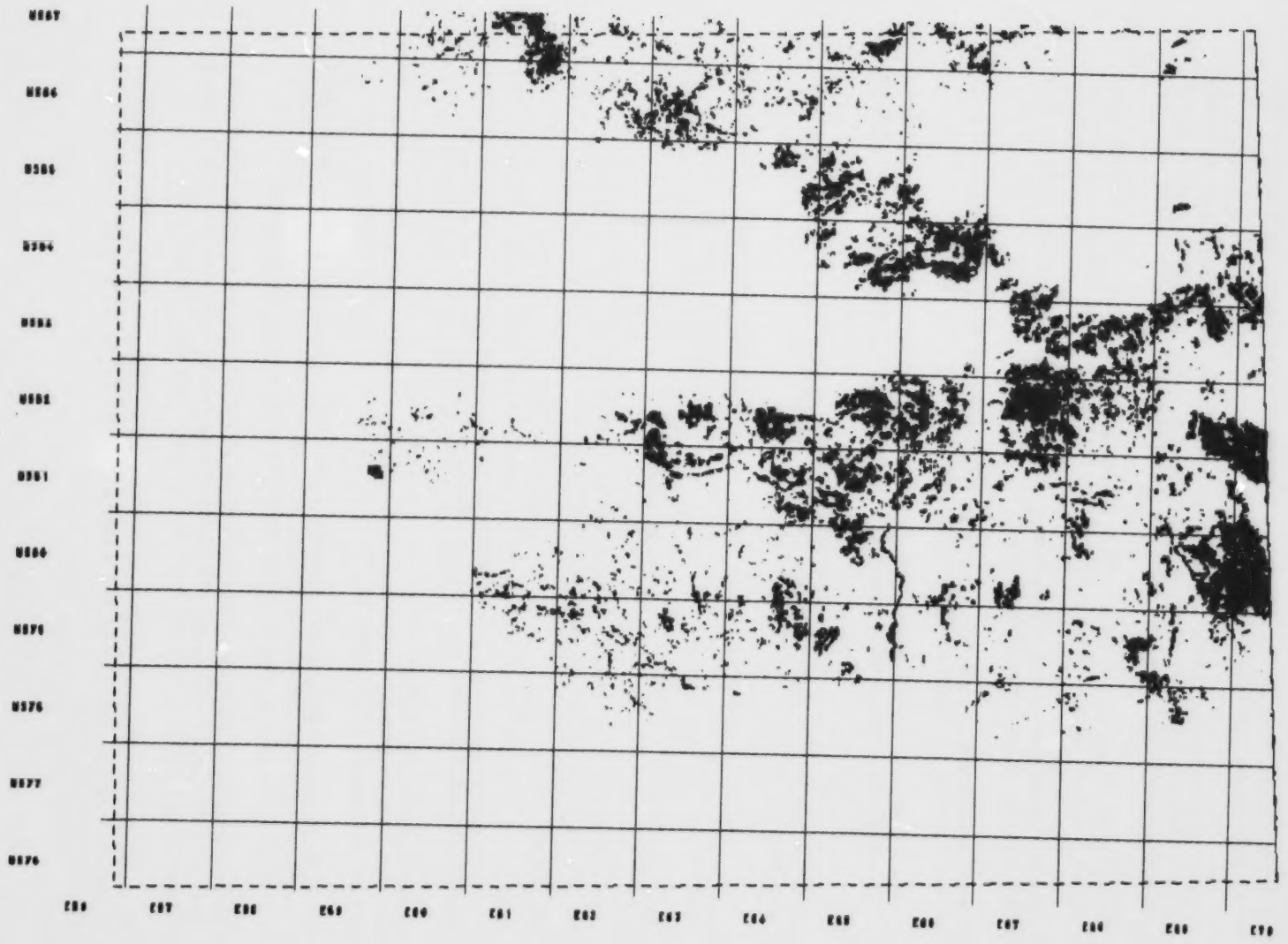


FIGURE 2 : Planning map of potential silviculture treatment areas generated by merging shaded NSR maps. Scale 1:250,000.

PRODUCTS AND USERS

I would like at this time to mention some of the users and uses of our data and show you some of the products generated by various GIS suppliers from our grid-cell files.

Our primary user is the Timber Management Section of our own Branch, whose responsibilities include negotiation of Forest Management Licence Agreements, monitoring of cutting plans, development of harvest volume schedules and establishment of long run sustainable yield projections.

Secondly, Weyerhaeuser Canada Ltd. of Prince Albert has utilized our inventory on an ongoing basis. Complete grid-cell coverage for their FMLA operating area has been provided to them in the last year. Conversion of this data for their own GIS has given them a solid database on which to build their own systems. Grid-cell summaries have also been utilized by Weyerhaeuser Head Office in the U.S.A., as source data for their high yield forest modeling of the Prince Albert operations.

Numerous forestry and resource management consultants have utilized our data for studies of park areas, alternate land use proposals, environmental impact studies and analyses of proposed sawmill locations.

A project currently in progress, which makes extensive use of the grid-cell forest coverage, is a knowledge based Forest Fire Management System being developed for Saskatchewan by researchers at Forestry Canada in Edmonton.

Our own Silviculture Section has based a number of renewal programs on maps of potential silviculture treatment areas identified through grid-cell mapping.

The next three slides are examples of forest cover maps, or derived products, generated by different GIS systems from our grid-cell files:

a) TYDAC using the SPANS system
b) TERRASOFT
c) PAMAP

CONCLUSION

Lastly, I would like to share with you some of our plans for the future. In addition to the long list of databases and products that we intend to develop for other Branches such as Fisheries, Wildlife, Parks, Resource Lands, Forest Protection, Regional Operations, etc., we are experimenting with some efficiencies of operation.

In the near future we will be embarking on a process of capturing stand attribute information digitally at the photo interpretation level, verifying it at the manuscript drafting level and automatically transferring it to the GIS as clean attribute information. All of this will be executed on a Local Area Network installation.

Our photo block adjustment process is currently automated but transferal of control points to base maps is done manually. We are working towards a process of generating photo control points on a micro (using Schutt's Bundle adjustment process) and transferring them directly to the GIS for plotting on manuscript mylar.

Our next major undertaking will be development of procedures for access to the GIS by personnel in Regional Offices. This will be developed simultaneously with loading of maps and development of 'user friendly' inquiry systems. Training of staff will play a major role in the effective implementation of this facility.

I would like to close my presentation on a positive note. We see many challenges ahead of us, but our enthusiasm and the progress we have experienced so far will contribute immeasurably to the successful implementation of GIS technology in Saskatchewan.

THE ROLE OF GIS IN PROVINCIAL INVENTORIES

Frank Hegyi

Director
Inventory Branch
B.C. Forest Service
Victoria
British Columbia

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Since the British Columbia Forest Service first acquired a computer assisted mapping system in 1978, its focus has shifted from computer assisted mapping to the development of up to 20 overlays in the context of a Geographic Information System (GIS). Further requirements have included integration with Satellite Image Analysis, production of colour enhanced thematic maps, overlays with digital terrain models and the incorporation of economic parameters for planning purposes. The GIS developed by the B.C. Forest Service meets all of these needs, together with high quality mapping, cost effective data handling and multiplatform capability, in a high throughput environment.

INTRODUCTION

Ten years experience with an operational GIS has revealed several key factors. First, user needs are changing constantly concerning the functionalities required of the system and the number of resource overlay levels needed to be processed. Hence, GIS with high quality cartographic capabilities may encounter operational problems as the number of levels of overlays increases. Secondly, the introduction of PC-based GIS significantly reduced the unit cost of production. However, the PC-based systems also encountered operational problems as the desired level of throughput of digitized maps increased. Thirdly, GIS functionalities have not completely satisfied client needs. Integration with Satellite Image Analysis has become a major requirement as digitized maps need to be updated. Utilization of digital elevation models has also become increasingly important with the current emphasis on determining economic operability.

In this paper, the author highlights the role of GIS in Provincial forest inventories as developed during the past ten years and illustrates current and future trends through the B.C. experience.

THE REVOLUTION

GIS is revolutionizing not only Provincial inventories, but also resource management practices. This revolution was initiated ten years ago and, like most revolutions, has involved commitment to the cause, as well as resistance to change, and has created both victors and victims. The spark which ignited this revolution was the frustration caused by the tediousness of manual drafting procedures and their inefficiency in handling large volumes of resource inventory maps. Initially the vision was simply to automate drafting techniques with the aid of a computer, but gradually expectations have grown far beyond this original concept. The new converts have demanded the capabilities of a fully functioning GIS. Early versions of GIS required minicomputers, such as the PDP 11/70 and the VAX systems. The cost of single station systems generally ranged from $200,000 to $300,000, resulting in at least a million dollar investment for those agencies involved in large-scale production. Added to this was the high cost of system maintenance and the enhancements necessary to make GIS fully operational. Consequently, the cost of digitizing a resource inventory map was relatively high and the new technology did not offer any financial benefits over manual procedures. Gains were made, however, in a reduced investment in manpower and in increased throughput. Also, once maps were digitized, updating them became highly cost-effective.

As the technology developed, vendors capitalized on opportunities to overlay several resource maps. Those who used a raster or relational data management approach, generally succeeded in deriving the necessary geo-referenced information, but at the expense of graphics quality. On the other hand, vendors who strived to maintain cartographic excellence opted for vector-based polygon overlays, resulting in cumbersome data processing procedures. The temporary victims of this phase of the revolution were the users. This was largely due to their belief that GIS capabilities were almost a practical reality. This belief was substantiated through vendor demonstrations which conveniently involved small data files related to only portions of maps. However, casualties started to occur, once GIS was implemented in an operational mode, severely impacting map production throughput. The advent of personal computers has diffused, to a certain extent, the growing potential for skirmishes between vendors and clients. The cost of GIS systems can now be reduced to approximately one third of predecessors, while at the same time, their capabilities are constantly improving. However, systems which are completely PC-based have proven to be limited in their ability to handle large volumes of maps. Although cost-effective, these systems can impede operational efficiency.

Vendors who have opted to become comrades-in-arms with users have generally offered a multi-platform solution for their product. Their systems can be used in the PC mode for data loading, while providing a mainframe solution for processing large volumes of maps and geo-referenced resource information. In such environments, the PC-based systems are generally connected through a network, therefore providing a full range of capabilities in a cost-effective manner. Progress in Satellite Image Analysis techniques has shifted the original focus of the GIS revolution. Vendors of image analysis systems have mounted a serious offensive on their GIS counterparts, with the objective of territorial gains. Once again the users have become the victims for believing that the new weapons in this offensive will provide the ultimate solution.

Since most image analysis systems are raster-based, they pose the same disadvantages as their comparable GIS opponents, in offering mediocre graphics capabilities. In order to overcome this setback, some users have rallied in a counter-revolutionary role by forcing GIS and image analysis systems vendors to integrate the capabilities of their products.

As new recruits have joined the ranks of the pioneering vendors, graphics and data management capabilities of the various systems have reached comparable levels. In search of new opportunities, some vendors have developed capabilities far beyond the original GIS concept. For example, high quality graphics and efficient data management and retrieval have been combined with colour enhanced thematic map production. Recently, the incorporation of digital terrain models has become the main focus of both GIS and image analysis vendors.

Learning from earlier experiences, users have become gun-shy in believing unconditionally in the newly resulting products. While perspective views of watersheds appear to be highly sought after GIS products, the reality of the technical difficulties in processing large volumes of data suggests that users should proceed with cautious optimism. The triumphs of this revolution have been the dramatic emergence of cost- effective GIS systems with a wide range of functionalities. For example, in the B.C. Forest Service, the cost of creating a digital forest cover map file has decreased from approximately $7,000 to $1,200. At the same time, the number of resource overlays has increased from six to nineteen. To date, approximately 5 000 of the 6 600 forest cover maps in the Province have been digitized and the production of colour enhanced thematic maps is fully operational. GIS and Satellite Image Analysis systems have been fully integrated and are used for updating the Province's maps on a two to three year cycle. GIS also plays a significant role in the ten year reinventory program.

THE AFTERMATH

Future applications of GIS technology will continue to be influenced by the increasing emphasis on resource use allocation. Although many resource use managers were initially sceptical of the new technology, their acceptance of its value as a decision support tool is becoming more widespread. GIS is proving to be a cost-effective aid to land use allocation and forest management. Its role in the delineation of economically operable forested areas is being recognized by progressive resource managers. Benefits to the Provincial economy in this area could be in excess of several million dollars annually. In timber supply analysis, the major influence of GIS will be its ability to geo-reference individual forest stands in order to facilitate site-specific planning and silvicultural operations. Harvest planning models will increase the use of GIS in large-scale operations, especially through the determination of economic operability, annual allowable cut and land use allocation. Technical enhancements of GIS are likely to occur at a more rapid rate than during its early development. This prediction is based mainly on the recent explosion in hardware development. For example, the introduction of multi-tasking PC systems and larger volume storage devices with gigabyte capacities will strongly influence future software applications. Consequently, the operational lifespan of GIS systems will be reduced from the current five years to three. That is, the rate of enhancements is expected to be such that after three years, a particular hardware/software configuration may become counterproductive compared to newer alternatives. This will create a dilemma for long-range system planners, central agencies, executives and boards of directors who may take up to a year to approve requests by hopeful GIS users. With such rapid technological development, the configuration initially proposed may be obsolete by the time acquisition occurs. Emphasis on future GIS configurations will be on distributed processing. Many of tomorrow's users will be in district offices where site-specific planning and decisions are made. Hence, increasing demands will be made on vendors to provide user-friendly systems. GIS developments have been described in this paper through a metaphor of revolution. This has been prompted by the strong belief that the most progress appears to have been achieved by agencies who have made a major commitment to the technology, plunging in, rather than awaiting its gradual evolution. Delays in decisions to acquire GIS have prolonged the continuation of tedious and costly manual systems, and have prevented the use of current information by resource managers in a flexible and timely manner. Further, the impact of these delays has often been to incur costs far in excess of the proposed acquisition.

CONCLUSION

Experience in British Columbia has resulted in the following conclusions:

1. Initial specifications of the user may not contain the full range of requirements that a GIS needs to satisfy. As the data are being digitized, additional requirements are introduced, which can seriously delay initial digital conversion plans.

2. There is a wide range of capabilities among GIS systems, both in terms of graphics and data management. Individual systems which excel in certain areas may not be able to maintain their advantage as the user increases the size of the digitized data base.

3. Demonstrations by vendors using single maps or only portions of maps may be misleading. Therefore, there may appear to be few differences in the capabilities of the various GIS systems currently on the market. However, there may be considerable deviation in cost-effectiveness and operational production throughput.

4. GIS systems which appear to be expensive to acquire may prove to be more cost-effective than their lower priced counterparts. The cost of acquisition of a typical GIS can be justified over a period of 3 years and the unit cost of production over time is a realistic measure of cost-effectiveness.

5. Full integration of GIS and Satellite Image Analysis becomes an operational requirement in land use planning as soon as the digitized land information requires update.

6. Increasing emphasis on distributed processing at a local level will necessitate the development of more user-friendly GIS systems.

7. Currently, only a few vendors offer an operational multi-platform GIS, with the added capabilities of producing colour enhanced thematic maps, integrating with Satellite Image Analysis systems and processing digital elevation data in a high throughput environment.

THE PRACTICAL APPLICATION OF GIS IN FOREST RESOURCE MANAGEMENT

Chris Hermansen

Timberline Forest Inventory Consultants
Suite 302 958 West Eighth Avenue
Vancouver B.C. V5Z 1E5

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

GIS provides the capability to structure forest resource information for resource modeling, and can also assist in reporting on management decisions derived from such models. Design of models that can be efficiently implemented, allowing extensive use without requiring enormous amounts of computer resources, is not a simple problem. Some models limit spatial relationships, economic concerns, and short-term planning to achieve globally optimal resource usage. Others ignore the issue of optimality and provide a flexible and realistic approach to the physical parameters. The level of detail of information potentially available from a GIS demands a similarly sophisticated approach to modeling.

1. INTRODUCTION

Management of forest resources has become a complicated process in the 1980s, with multiple-use demands on an ever-dwindling resource. Planners, confronted with this complexity, have resorted more and more to computer-based modeling tools to provide objective assistance in determining resource allocation. In turn, many of these tools, developed in the 1970s, have begun to show their limitations, particularly in dealing with problems that have a significant spatial component. Such problems are common when organizations want to plan at the operational level, and have access to good spatial information (usually derived from data managed by a geographic information system).

The trend in the late 1980s is moving away from strictly long-term, sustained yield forest management models to hybrid systems that also incorporate short-term, multiple-use simulation capabilities. Geographic information systems form an essential component of such systems, both as sources of geographic data (to drive other computer programs) and as tools for representing various themes for presentation and discussion.

2. SOME BASIC COMPONENTS OF THE PLANNING PROCESS

Planning issues can be broadly divided into two categories: strategic and operational.

Strategic planning typically involves tracking relatively few parameters that are of primary importance (for example, total wood volume) on large land bases over long periods of time. The purpose of this type of planning is therefore one of demonstrating the continuing viability of a resource given a particular set of management assumptions.

Operational planning, in contrast, commonly uses a much greater number of parameters (some relating to spatial distribution of the resource, others to secondary aspects of the resource) on smaller land bases over shorter periods of time. The typical application of this type of planning might be to choose an "optimum" location for a sawmill, or to construct a minimum-cost road network for resource extraction.

Both types of planning can be oriented either toward single or multiple use of the resource. For example, a forest may be identified as having high potential for recreational or wildlife use and low potential for harvesting.

The mandate of the planning organization will often obscure some issues while emphasizing others; for instance, the B.C. Ministry of Forests is empowered to manage the forests for resource extraction and range values while taking into account integrated resource demands. The B.C. Ministry of Tourism, on the other hand, is most concerned that forest harvesting activities do not have a negative impact on the recreational potential of forest areas.

Even a mandate to encourage a specific use of the resource can engender complexities in the process. A strong orientation toward stand management, as in some European countries, places more emphasis on the portion of the forest left standing than that harvested. In contrast, resource modeling systems such as MUSYC, developed in the U.S., are designed to extract optimal resource value from the forest - the bias being toward the portion of the forest harvested.

Planning methodologies reflect the underlying management structure. In a centralized organization, all data relevant to the planning exercise is supplied to the department responsible. Decentralized organizational structure typically involves field planning units that supply results of detailed operational level planning to a central strategic body.

In all of the above points, the common theme is an evaluation of policy. For private forest companies, harvesting must be planned to coincide with mill requirements, market conditions, and government regulation. Governments must ascertain that resource usage is in the public good. Global organizations such as the World Bank or the United Nations track large-scale processes as a responsibility to their member nations. In all cases, the organization will use some type of planning model(s) to predict the effects of policy, and then monitor the actual results. This type of planning has three primary requirements: policies that address real issues; data col- lection and reporting procedures that allow objective evaluation of the effects of these policies; and the ability to alter policy as necessary to better meet objectives.

As resources become scarce in relation to demands, planners must have better information and more efficient techniques in order to provide that critical policy assessment.

3. DEVELOPMENT OF PLANNING MODELS

The development of planning models is a several stage process. Typically, the process of planning is only applied to a resource that has a larger demand than supply, and the larger the gap between supply and demand, the more planning effort expended.

As an example, planning models applied to forest resource consumption in the 1950s and 1960s were relatively cursory, really only demonstrating that there was enough "harvestable" wood (often based upon a somewhat dubious definition of harvestable) to meet the requirements of existing industry in the next 75 years or so. However, two issues have dramatically altered this planning model: first, the realization that such a policy might have very dramatic effects on the longer-term supply of wood (the so-called "falldown" effect); and second, the growing importance of non-consumptive forest users at the same time that the actual size of the resource base was dwindling.

Confronted with this situation, planners realized that two essential improvements were necessary: new planning models that took into account multiple use, and new methods of data gathering and reporting. Furthermore, because of the growing level of participation of many special interest groups, both improvements had to minimize, to the greatest extent possible, the subjective nature of planning.

The new planning models that were put into place centered around computer systems developed for similar reasons in the U.S. The first such model was Timber-RAM, a computer program that attempted to optimize the total output of the forest (in volume or dollars) over a fairly long planning horizon (typically at least two rotations). This model suffered from several deficiencies; it did not allow direct integration of multiple-use concerns; it worked on large time divisions (typically decades), which limited its operational utility; despite the fact that constraints typically used limited the gains from optimization, it required the integration of a linear programming system that increased computer-related planning costs enormously; and because it was volume (or dollar) oriented, it gave no indication of how to geographically implement the derived plan. However, Timber-RAM did demonstrate one important point in a clear and unequivocal fashion: current forest management policies encouraged a level of cut on mature stands that could not be sustained once harvesting moved to younger second-growth stands. Furthermore, as those same policies, along with a strong market for lumber and pulp, had encouraged the accelerated harvest, the issue of reduced cutting levels (and the more subtle issue of an altered resource base that existing production facilities could not make economic use of) had to be dealt with soon to avoid a potentially disastrous economic change in the near future.

Timber-RAM was replaced with MUSYC, another optimization system from the U.S. Although MUSYC allowed a more flexible approach to incorporating area and volume information, as well as more sophisticated economic modeling, it neither provided the ability to suggest exactly how (in geographic terms) that optimal harvest policy might be achieved, nor could it address incorporating the relative wealth of short-term concerns into the long-term planning horizon.

The Inventory Branch is currently investigating ways to replace the MUSYC based system with one that combines detailed short-term information with the broad, longer term approach. This is the type of hybrid system mentioned in the introduction: the integrated planning model.

4. INTEGRATED PLANNING MODELS

For B.C. foresters, integrated planning models are most easily understood as an extension (or modification) to the management and working plan process used to allocate cut in timber supply areas (T.S.A.).

Each licensee is allocated a portion of the total cut in the timber supply area. In order to define where that cut will come from, the licensee will designate chart areas, and within these chart areas, first- and second- pass cut blocks that cover the short-term.

One possible way of approaching this, in terms of a planning model, is to determine the remaining forest inventory at each stage of first- and second-pass removals, and then to assess the remainder of the T.S.A. to see if it will continue to support the current cut level.

Many improvements to the basic process can be envisioned; for example, the licensees could make use of some sort of optimization techniques to select the harvesting sequence for cut blocks, or even use the computer to automatically generate the "best" cut block boundaries according to some set of economic criteria. The results of the short-term plan could be used to provide "starting conditions" for an optimization program.

One step that is missing from the current planning process is the immediate assessment of first- and second-pass removals on long-term timber supply; instead, the resource is updated on a periodic process after removals have occurred. Although depletion monitoring is obviously a crucial part of maintaining an up-to-date picture of the inventory, the most immediate consequence of this type of management is that short-term decisions having an adverse effect on the long-term situation only get "discovered" after they are taken.

The hallmark of a good integrated planning model, then, is that it provides a mechanism to assess the long-term effects of short-term management policies.

5. THE ROLE OF GIS IN INTEGRATED PLANNING MODELS

The main deterrent to implementing an integrated planning model has revolved around an inability to assess, in a timely fashion, the results of a proposed operational (i.e. short-term) plan. The single most important development in computing systems that makes this type of planning feasible is the geographic information system.

Geographic information systems supply many facilities, but in the planning context the two that count are the integration of spatial and attribute data and the capability to combine this information from several different "layers".

As a simple example, the planner might start off with a long-term analysis of a particular T.S.A. that demonstrates the feasibility of a certain level of cut in certain volume types, subject to a particular set of constraints.

Next, lines are digitized and attributes are entered corresponding to chart boundaries (this would be referred to as the "chart boundary layer"), and similarly for first- and second-pass cut blocks (the "cut block layer"). These layers can be combined with the forest cover layer in a process termed "topological overlay" to create polygons that have chart number, first/second pass information, and forest cover data.

The planner could then print out reports that show, for example, the volume, species, age class, and site class information for first pass, second pass, remaining chart area, and non-charted land. This type of reporting can be used to adjust the cut block boundaries until some desired harvest level and species mix is obtained, and then to determine the harvest sequence that will deliver a proper diet to the mill(s).

Finally, by reporting on area (by volume types used within the long-term analysis) for non-charted land, the long-term model could be re-run, with the same definitions and constraints, to ensure that the level of cut could be supported after the short-term management activities had taken place. In the case of a model incorporating Timber RAM or MUSYC, constraints can be applied to the first- and second-pass areas so that they are "cut" in the appropriate time periods.

After several iterations of this process, an integrated resource use plan will have been produced that meets stated organizational goals. This plan must typically be presented to various regulatory bodies and special interest groups. The purpose of these meetings is twofold: first, to verify that the plan meets existing goals, and second, to ensure that it does not conflict with other interests that were not represented in the original plan.

The geographic information system can provide presentation material for these meetings in a convenient and economical fashion. For example, the engineering group can verify that facilities (roads, mills, etc) requirements are met in the plan by: viewing thematic maps showing the harvest sequence; evaluating reports estimating the total roadbuilding requirements to implement that sequence; and ensuring that the wood flow estimates

meet mill needs. Equipment managers can use slope, forest cover, and soils maps and reports to schedule purchase of logging equipment. Environmental concerns and community groups can examine, with the assistance of three-dimensional models and soils maps, the impact of the proposed harvesting plan on sensitive areas.

If any areas in the plan are found to be seriously deficient, the additional goals can be incorporated into the modeling process and the analysis redone.

Critical to the function of this methodology is the turn-around time between formulation of policy and presentation of results. With a commitment to accurate, up-to-date base data, collected at a level of detail that is appropriate to the operational planning process, the geographic information system speeds up the overlay and reporting process to the point where several map sheets per hour can be processed, once the appropriate boundaries are entered.

As an example of the importance of this, consider the situation where, based upon a review process, the location of the chart boundaries were changed on ten out of fifty map sheets. In a well-implemented database, the planner could simply delete the old chart boundary and add the new ones on each map sheet, a process that might take perhaps ten minutes per map. The planner would then re-compute the overlays, taking about ten more minutes per map. The reports showing volume and species would then be re-run for the entire database, consuming probably another hour, including printing. The total time involved is less than five hours, and the likelihood of an error that might readily occur in a manual system is extremely low.

6. A CASE STUDY

To illustrate some of the points above, consider the following case study.

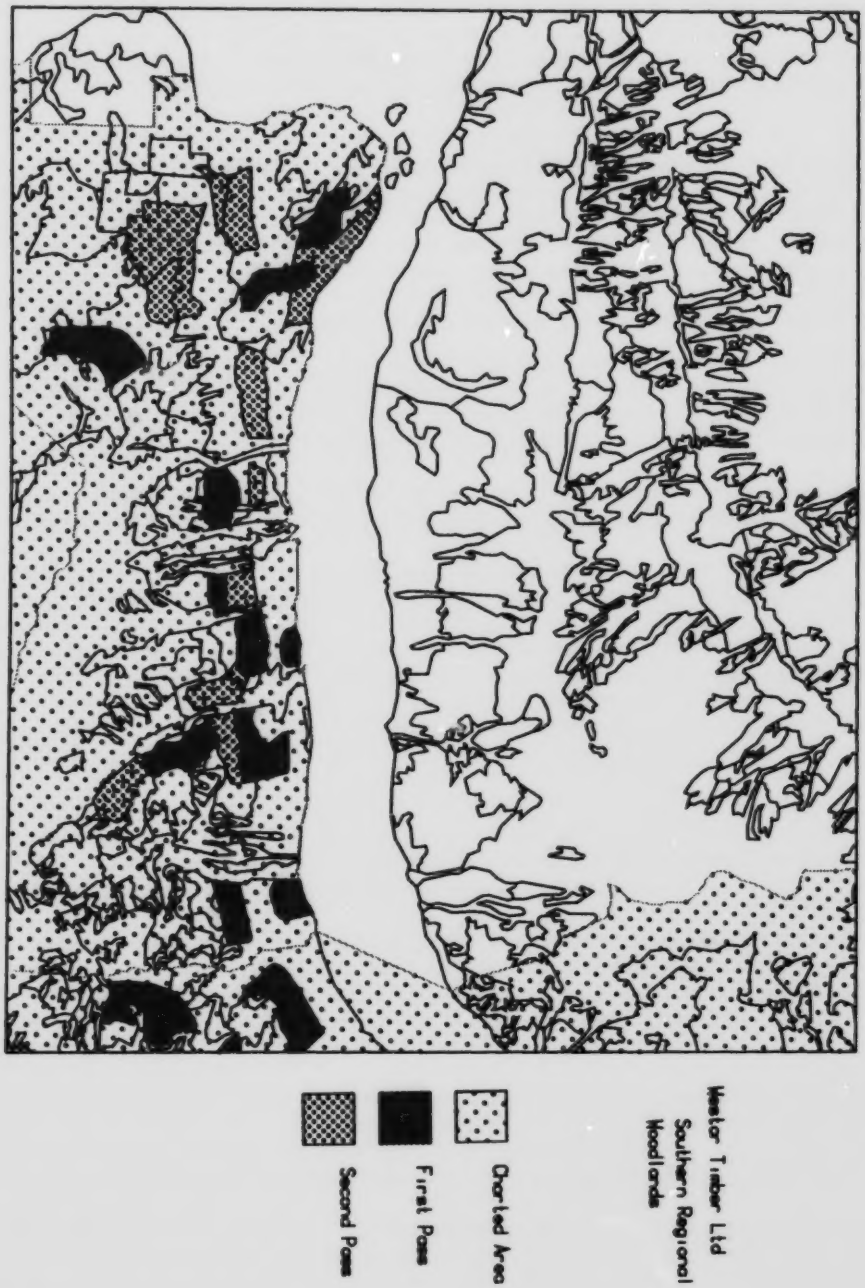
In one of their operating areas, Westar Timber Ltd. was required to produce a short -term plan showing chart areas, first- and second-pass cut blocks, and riparian reserves.

They began with B.C. Ministry of Forests 1:20 000 digital forest cover maps. These maps, provided by the Ministry at no charge, contain forest cover, basic planimetry, and administrative information.

Westar used a geographic information system to add chart, cut block, and riparian area polygons and attri- butes. At the same time, the maps were updated (from satellite imagery) for recent logging.

Please refer to the figures on the following pages:

FIGURE 1: A PLANNING MAP



Once all boundaries and attributes were in place, the GIS was used to combine the harvesting and forest cover information (a type of topological overlay known as "union") into resultant polygons that identified areas by forest type, chart, and one of: first/second pass and logging system, riparian area, or reserved.

FIGURE 2: A SUMMARY OF FIRST PASS INFORMATION

Westar Timber Ltd.
Short Term Timber Supply

89/01/23

Chart Number	Block Number	Logging System	Area (ha)	1st Pass Total (m3)	Fir (m3)	Balsam (m3)	Spruce (m3)	L Pine (m3)	Other (m3)
AB	1	WS	57.07	12245.89	.00	.00	7853.55	4392.34	.00
AB	2	SS	39.12	9387.81	.00	.00	7039.15	2348.66	.00
AB	3	SS	39.55	9301.52	.00	.00	6916.26	2385.28	.00
AB	4	C	37.48	8491.98	6.91	1.98	6306.77	2175.64	.68
AB	5	SS	33.71	7809.00	.00	.00	5602.39	2206.62	.00
AB	6	SS	40.24	8939.25	.00	.00	6166.27	2772.99	.00
AB	7	SS	29.99	6029.39	.00	.00	3646.33	2383.06	.00
AB	8	WS	55.17	11386.11	.00	.00	7876.67	3509.44	.00
AB	9	WS	38.92	9170.77	.00	.00	6878.07	2292.69	.00
AB	10	C	51.81	12522.56	2616.90	749.63	6720.51	2176.56	258.96
AB	11	C	66.62	19678.38	11865.26	3398.90	2646.33	593.72	1174.17
AB	12	SS	63.94	19181.14	12275.93	3516.54	1854.18	319.69	1214.81
AB	13	SS	35.39	10617.16	6794.98	1946.48	1026.33	176.95	672.42
AB	14	WS	.06	19.29	12.35	3.54	1.87	.32	1.22
AB	All	All	589.07	144780.25	33572.33	9617.07	70534.66	27733.92	3322.26
C3	21	WS	30.57	9113.43	5832.59	1670.80	880.96	151.89	577.18
C3	22	WS	52.86	15779.98	9998.66	2864.20	1604.46	323.21	989.45
C3	23	WS	42.64	12455.91	7971.79	2283.58	1204.07	207.60	788.87
C3	24	C	28.71	8570.62	5429.46	1555.31	872.33	176.23	537.29
C3	25	WS	9.23	2767.56	1771.24	507.39	267.53	46.13	175.28
C3	26	WS	15.24	4566.39	2921.35	836.84	442.32	76.79	289.09
C3	32	WS	34.91	10473.71	6703.18	1920.18	1012.46	174.56	663.34
C3	33	SS	63.18	18954.18	12130.68	3474.93	1832.24	315.90	1200.43
C3	34	SS	17.83	4987.92	.00	.00	3739.70	1248.22	.00
C3	35	SS	39.56	11014.48	14.39	4.12	8243.14	2751.41	1.42
C3	36	C	46.54	12901.89	5777.06	1654.89	3271.53	1626.73	571.89
C3	37	C	53.84	14409.12	6895.29	1975.21	3291.86	1564.41	682.35
C3	38	C	41.20	11383.65	3318.31	950.56	5147.70	1638.71	328.37
C3	39	C	47.16	14138.85	8976.17	2571.30	1440.96	262.15	888.27
C3	40	WS	44.15	10122.01	.00	.00	6711.44	3410.58	.00
C3	41	C	40.55	11953.27	5756.55	1649.01	3088.48	889.58	569.66
C3	42	C	37.33	10262.78	.00	.00	7622.40	2640.38	.00
C3	43	C	49.73	14898.26	9447.74	2706.38	1529.13	280.08	934.93
C3	44	SS	22.63	4752.77	.00	.00	2942.19	1810.58	.00
C3	45	WS	58.52	12143.78	.00	.00	7517.88	4625.90	.00
C3	All	All	778.39	215650.58	92944.44	26624.71	62662.78	24221.03	9197.63
C4	66	SS	17.63	5138.77	2044.63	585.70	1762.46	543.64	202.33
C4	71	WS	17.07	5122.10	3278.14	939.05	495.14	85.37	324.40
C4	72	WS	15.97	4789.57	3065.33	878.09	462.99	79.83	303.34
C4	74	WS	33.87	8798.77	3596.66	1030.29	2511.19	1304.71	355.92
C4	75	WS	8.90	2670.71	1709.25	489.63	258.17	44.51	169.14
C4	76	WS	18.39	5506.95	3507.97	1004.89	545.79	101.16	347.14

Timberline Computing Services

Finally, the resultant information was used as input to MUSYC, combined with TSA planning policies volume data, to verify the long term feasibility of the logging plan. Some summaries from MUSYC follow:

FIGURE 3: AGGREGATE AREA DATA

WORKING GROUP	LAND CLASS	CONDITION CLASS FOR EXISTING STANDS	CONDITION CLASS FOR REGEN STANDS	ST KD	CT KD	AGE	AREA HA	PROPOR. ACCESSIBLE BY PERIOD 1	2	3	4	5
Pass 1	Area B	F.S GMP	F.S GMP		E	13	0.008	1.00				
Pass 1	Area B	F.S GMP	F.S GMP		E	19	0.091	1.00				
Pass 1	Area B	F.S GMP	F.S GMP		E	25	0.075	1.00				
Pass 1	Area B	Pl GM	Pl GM		E	19	0.057	1.00				
Pass 1	Area B	Pl P	Pl P		E	25	0.273	1.00				
Pass 1	Area B	PlMix P	PlMix P		E	25	0.069	1.00				
Pass 1	Area B	Other GMP	Other GMP		E	19	0.004	1.00				
Pass 1	Cnt 3	F.S GMP	F.S GMP		E	19	0.277	1.00				
Pass 1	Cnt 3	F.S GMP	F.S GMP		E	25	0.207	1.00				
Pass 1	Cnt 3	Pl GM	Pl GM		E	19	0.151	1.00				
Pass 1	Cnt 3	PlMix GM	PlMix GM		E	19	0.137	1.00				
Pass 1	Cnt 3	Other GMP	Other GMP		E	9	0.001	1.00				
Pass 1	Cnt 4	F.S GMP	F.S GMP		E	13	0.017	1.00				
Pass 1	Cnt 4	F.S GMP	F.S GMP		E	19	0.014	1.00				
Pass 1	Cnt 4	F.S GMP	F.S GMP		E	25	0.058	1.00				
Pass 1	Cnt 4	Pl GM	Pl GM		E	19	0.015	1.00				
Pass 1	Cnt 4	PlMix GM	PlMix GM		E	19	0.007	1.00				
Pass 1	Cnt 5	F.S GMP	F.S GMP		E	19	0.115	1.00				
Pass 1	Cnt 5	F.S GMP	F.S GMP		E	25	0.107	1.00				
Pass 1	Cnt 5	Pl GM	Pl GM		E	19	0.010	1.00				
Pass 1	Cnt 5	PlMix GM	PlMix GM		E	19	0.081	1.00				
Pass 1	Cnt 6	F.S GMP	F.S GMP		E	25	0.158	1.00				
Pass 1	Cnt 6	Pl GM	Pl GM		E	19	0.137	1.00				
Pass 1	Cnt 6	PlMix GM	PlMix GM		E	19	0.142	1.00				
Pass 1	Cnt 7	F.S GMP	F.S GMP		E	19	0.244	1.00				
Pass 1	Cnt 7	F.S GMP	F.S GMP		E	25	0.175	1.00				
Pass 1	Cnt 7	PlMix GM	PlMix GM		E	19	0.025	1.00				
Pass 1	Cnt 7	Other GMP	Other GMP		E	11	0.019	1.00				
Pass 1	Cnt 7	Other GMP	Other GMP		E	19	0.011	1.00				
Pass 2	Area B	F.S GMP	F.S GMP		E	19	0.039	0.0	1.00			
Pass 2	Area B	F.S GMP	F.S GMP		E	25	0.003	0.0	1.00			
Pass 2	Cnt 3	F.S GMP	F.S GMP		E	25	0.058	0.0	1.00			
Pass 2	Cnt 4	F.S GMP	F.S GMP		E	13	0.021	0.0	1.00			
Pass 2	Cnt 4	F.S GMP	F.S GMP		E	19	0.017	0.0	1.00			
Pass 2	Cnt 4	F.S GMP	F.S GMP		E	25	0.130	0.0	1.00			
Pass 2	Cnt 4	Pl GM	Pl GM		E	19	0.002	0.0	1.00			
Pass 2	Cnt 4	PlMix GM	PlMix GM		E	19	0.001	0.0	1.00			
Pass 2	Cnt 4	Immature	Other GMP		E	1	0.028	0.0	1.00			
Pass 2	Cnt 4	Unstocked	Other GMP	N	E	0	0.004	1.00				
Pass 2	Cnt 5	F.S GMP	F.S GMP		E	19	0.245	0.0	1.00			
Pass 2	Cnt 5	F.S GMP	F.S GMP		E	25	0.069	0.0	1.00			
Pass 2	Cnt 5	PlMix GM	PlMix GM		E	19	0.056	0.0	1.00			
Pass 2	Cnt 5	Immature	Other GMP		E	1	0.002	0.0	1.00			
Pass 2	Cnt 5	Immature	Other GMP		E	7	0.001	0.0	1.00			
Pass 2	Cnt 6	F.S GMP	F.S GMP		E	19	0.002	0.0	1.00			
Pass 2	Cnt 6	F.S GMP	F.S GMP		E	25	0.094	0.0	1.00			
Pass 2	Cnt 6	Pl GM	Pl GM		E	19	0.015	0.0	1.00			
Pass 2	Cnt 6	PlMix GM	PlMix GM		E	19	0.080	0.0	1.00			
Pass 2	Cnt 7	F.S GMP	F.S GMP		E	19	0.148	0.0	1.00			
Pass 2	Cnt 7	F.S GMP	F.S GMP		E	25	0.034	0.0	1.00			
Pass 2	Cnt 7	PlMix GM	PlMix GM		E	19	0.039	0.0	1.00			

FIGURE 4: AREA SUMMARIES

LND CLS	WORKING GROUPS Pass 1	Pass 2	Unallocate	Riparian	ALL WG
Area A			2.24		2.24
Area B	0.58	0.04	2.62	0.06	3.30
Area C			0.11		0.11
Area D			0.02		0.02
Area E			0.10		0.10
Area F			0.10		0.10
Cht 3	0.77	0.06	4.87	0.02	5.72
Cht 4	0.11	0.20	0.95		1.27
Cht 5	0.31	0.37	2.50	0.01	3.19
Cht 6	0.44	0.19	2.20	0.03	2.85
Cht 7	0.47	0.25	2.50	0.12	3.34
ALL LC	2.69	1.12	18.22	0.23	22.25

FIGURE 5: MANAGEMENT ALTERNATIVES

WORKING GROUP	LAND CLASS	CONDITION CLASS	AGE	VOL TBL	ECN TBL	MGT TYP	THN CYC	ENTRIES FST	ENTRIES LST	HARVESTS FST	HARVESTS LST	HAR CYC	HAR TYP	PCT PER	REL PER	OCL PER	CONV RATIO	FLG
Pass 1	Area B	F,S GMP	13	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Area B	F,S GMP	19	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Area B	F,S GMP	25	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Area B	Pl GM	19	2	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Area B	Pl P	25	3	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Area B	PlMix P	25	5	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Area B	Other GMP	19	6	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 3	F,S GMP	19	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 3	F,S GMP	25	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 3	Pl GM	19	2	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 3	PlMix GM	19	4	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 3	Other GMP	9	6	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 4	F,S GMP	13	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 4	F,S GMP	19	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 4	F,S GMP	25	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 4	Pl GM	19	2	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 4	PlMix GM	19	4	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 5	F,S GMP	19	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 5	F,S GMP	25	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 5	Pl GM	19	2	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 5	PlMix GM	19	4	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 6	F,S GMP	25	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 6	Pl GM	19	2	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 6	PlMix GM	19	4	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 7	F,S GMP	19	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 7	F,S GMP	25	1	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 7	PlMix GM	19	4	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 7	Other GMP	11	6	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 1	Cht 7	Other GMP	19	6	0	0	0	1	1	1	1	1	CLEAR	0	0	0	0.0	
Pass 2	Area B	F,S GMP	19	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Area B	F,S GMP	25	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 3	F,S GMP	25	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 4	F,S GMP	13	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 4	F,S GMP	19	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 4	F,S GMP	25	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 4	Pl GM	19	2	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 4	PlMix GM	19	4	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 4	Immature	1	7	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 4	Unstocked	0	0	0	0	0	1	1	1	1	1		0	0	0	0.0	
Pass 2	Cht 5	F,S GMP	19	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 5	F,S GMP	25	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 5	PlMix GM	19	4	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 5	Immature	1	7	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 5	Immature	7	7	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 6	F,S GMP	19	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 6	F,S GMP	25	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 6	Pl GM	19	2	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 6	PlMix GM	19	4	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 7	F,S GMP	19	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 7	F,S GMP	25	1	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	
Pass 2	Cht 7	PlMix GM	19	4	0	0	0	2	2	2	2	1	CLEAR	0	0	0	0.0	

7. OTHER OPERATIONAL CONCERNS

Operational level planners must often be concerned with other planning issues than those discussed above. In the applications discussed below, a geographic information system is used to represent the data model, and in some cases, has the analysis software to produce the final results.

As new drainages are developed, road access must be planned. One interesting method involves deriving a road-building cost function based upon terrain and soil information produced from a digital terrain model and soil overlay. This cost function can be applied to a very fine rectangular mesh of tentative road paths using a technique known as line-in-polygon overlay. Once each section of the mesh has a cost attached to it, the "shor- test path" can be computed from selected supply points to some marshalling point (for example, from proposed cut blocks to the main road at the entrance of the drainage). This method was recently demonstrated by Doug Stewart of ESRI Canada.

In a large drainage, or when several drainages are being analyzed simultaneously, the planner may want to determine some type of optimal harvesting sequence. John Nelson at UBC has reported on this type of analysis.

The digital terrain model is of particular importance in resolving disputes over terrain-related issues. Typical GIS software allows computation of a "visibility index" over a fine mesh representing the surface of the earth, based upon a pre-defined set of viewpoints. The planner may select a set of viewpoints, perhaps along a road noted for scenic potential, use this feature to show where the highly visible areas are, and ultimately finalize logging boundaries accordingly. In more sophisticated models, a secondary terrain model that compensates for tree height can be "added" to the primary one. Westar Timber Ltd. has used this type of analysis along the Skeena River in northern B.C.

Planning for types of harvesting equipment can often be simplified by a combination of information from the digital terrain model and forest cover. Slope information is extracted from the terrain model to construct a set of "logging system" polygons that show which type of machinery is required to operate in a given area. This, combined with forest stand information, can be used to define the "total logging chance" for a given harvest pattern. Crestbrook Forest Industries Ltd. is beginning to use this capability in southeastern B.C.

8. POST-HARVEST ISSUES

One important concern not yet addressed in this paper is silviculture. In one sense, silviculture applications are just an extension of inventory applications: a few more attribute tables are defined to record history, and the update capabilities of the geographic information system are used to record the "new" forest polygons in the database.

This is a fairly glib description of a complex process, however. A good GIS should allow the planner to retain some sort of "audit trail" through the sequence of treatments applied. A more flexible approach might involve having a "silviculture layer" for each year; when all attributes for the layer are up to date, the forest cover layer could be (automatically) updated from that silviculture layer. In practice, the restrictions imposed by some GIS limit this type of design.

One interesting issue that GIS gives a strong appreciation of is reconciling proposed cut blocks with actual harvested areas. Planners can make use of low-cost update from satellite imagery to quickly obtain new boundaries; this information can be quite useful in monitoring and quantifying deviations from the harvest plan. Furthermore, if the overall shift in recent logging has been, for example, into a different species profile, some attention to availability of planting stock and related concerns may be required.

In any case, the GIS should provide all the capabilities necessary in this application: basic mapping and drafting; reporting on areas treated; priorizing areas for survey; and projective modeling of treatment types based upon prior forest stand attributes and ecosystem classification.

As a closing note, standards regarding the collection of silvicultural field data in B.C. are being developed by the Silviculture Branch of the Ministry of Forests.

9. SYSTEM CAPABILITIES

As many of the aforementioned applications have diverse data requirements (ranging from elevation to forest cover and soils), the key feature of a geographic information system in this area is flexibility. Some measure of flexibility can be determined by ensuring the GIS:

- can combine polygon and point or polygon and line data (for example, to apply slope and soil [polygon] information to road [line] features);
- can generalize point or line data into polygon structures (to construct right-of-way strips along roads, or soil polygons around soil pits);
- can convert point or line data with elevation information into a digital terrain model;
- can convert terrain information (elevation, slope, aspect) into polygon structures to allow interaction with other map features;
- can display point, line, or polygon information in a three-dimensional context (to provide visual representation of the interaction between the various data types);
- provides analysis modules to deal with structured data (for instance, network flow analysis that can be applied to road networks to determine shortest path);
- provides a direct coupling of attribute and spatial information so that the planner can use all of these tools without having to convert attribute data back and forth between a stand-alone database package and the GIS;
- provides utilities that allow straightforward interchange of spatial and attribute data with other GIS, minimizing the amount of "data recapture";
- allows data to be extracted from the system for use with existing modeling systems (such as FORPLAN), permitting integration with current methodology.

10. SUMMARY

The most important feature of a successful integrated planning system is flexibility: it should be able to analyze a situation using input and direction from many diverse sources, without massive amounts of redesign.

In turn, this flexibility requirement imposes itself on all the components of the system: the geographic information system, the programs used to schedule resource extraction, and so on.

Flexibility can have its negative aspects, however. The system must achieve a balance between a good representation of the problem, without sacrificing efficiency to the extent that the utility of the model is limited.

Finally, the procedures and the base data used in the modeling process must be sufficiently reliable that planners can have confidence in the model's predictions.

11. REFERENCES

The following publications provide further background material on planning models, linear programming, and geographic information systems.

General Technical Report RM-140: FORPLAN: An Evaluation of a Forest Planning Tool, Proceedings of a Symposium, November 4-6, 1986, Denver, Colorado, United States Department of Agriculture.

Burrough, P.A. 1986. **Principles of Geographical Information Systems for Land Resources Assessment**, Oxford Science Publications.

Covington, W.W. , D.B. Wood, D.L. Young, D.P. Dykstra, and L.D. Garrett. August 1988. **"TEAMS: A Decision Support System for Multiresource Management"**. IN: Journal of Forestry.

Gass, Saul I. 1975. **Linear Programming**, McGraw-Hill.

Johnson, K. Norman , Thomas W. Stuart and Sarah A. Crim. **FORPLAN Version 2: An Overview**. United States Department of Agriculture.

Navon, Daniel I. 1971. **Timber RAM Users' Manual, Part I: Smokey Forest Case Study**. U.S. Department of Agriculture.

Williams, D. , L. Dellert and P.Bunnell. 1988. **Proposed Forest Resource Analysis System (FRAS): Problem Analysis and System Concepts**. B.C. Ministry of Forests Inventory Branch.

DATA CONSIDERATIONS - SOME PRINCIPLES FOR ACCURACY AND RELIABILITY OF DATA IN A GIS SYSTEM

Kim Iles

Biometrician
MacMillan Bloedel Ltd.,
Nanaimo, British Columbia

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

A GIS is basically a tool that mines data and displays it. It doesn't clean it up, or maintain it, and seldom even looks to see if it's reasonable. If you don't give some thought to these problems you will get exactly what you deserve - and your employer will pay for it. The same people who installed your first computer system are back again. You remember that one - "...the money saver...". Well, it's still your job to see these things coming.

And now you have a chance to redeem yourself.

NATIONAL GEOMATICS DATABASES OF CANADA

Zul Jiwani

Geographic Information Systems Division
Energy, Mines and Resources
615 Booth Street
Ottawa, Ontario, Canada K1A 0E9

Gordon Plunkett

Canada Centre for Remote Sensing
Energy, Mines and Resources
2464 Sheffield Road
Ottawa, Ontario, Canada K1A 0Y7

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

The Federal Department of Energy, Mines and Resources (EMR) is the federal agency primarily responsible for coordinating the provision of positional and descriptive information of the Canadian land mass and surrounding waters. There are several national databases being developed, in various government departments, that store and process geographic information related to domains such as topography, soil, environment and hydrography, among others. This paper will outline what major national geomatics activities are being performed and what databases are currently available. In addition, the direction the federal government is taking, including the fostering of geomatics activities and standards in the public and private sectors, will be included.

INTRODUCTION

The Canadian federal government leads the world with the development of the first Geographic Information System (GIS). Known as the Canada Geographic Information System (CGIS), this system was developed in the early 1960s to store environmental information about the Canadian landmass. Clearly the computer systems upon which this GIS was developed have improved in speed and capacity many fold since the system was first implemented. However, the essential item in the CGIS is the database.

The federal government has a number of large data stores of information related to the Canadian landmass. Much of this data has for many years been stored in the form of paper maps, however digital storage and processing techniques are becoming more popular. The need to compile and provide data in digital format is becoming essential for many agencies, in particular for agencies with a mandate to provide wide area coverage.

EXISTING FEDERAL GEOMATICS ACTIVITIES

Numerous departments within the federal government are responsible for creating and maintaining geomatics information. Although almost every department has some geomatics activities, the most active departments are:

1. Energy, Mines and Resources; which is responsible for land mapping, some water mapping, aeronautical charts and remote sensing data acquisition.

2. Fisheries and Oceans; which is responsible for production and maintenance of nautical charts via the Canadian Hydrographic Service.

3. National Defense; which is responsible for the provision of maps, charts and geographic support for the Department and the Canadian Forces.

4. Environment Canada; which produces weather maps via the Atmospheric Environment Service and provides environmental information via the State of the Environment Reporting Branch.

5. Statistics Canada; which is responsible for reporting on the census and other cultural statistics.

6. Agriculture Canada; which created the Canadian Soil information System for mapping, describing and assessing Canada's soils.

The geomatics activities of each of these departments will now be elaborated upon.

ENERGY, MINES AND RESOURCES.

The Department of Energy, Mines and Resources has the largest mandate for collection and distribution of geomatics data within the federal government. There are many sources of data within the department, not all however, are available digitally. The major sources of geomatics data are within the Surveys, Mapping and Remote Sensing Sector (SMRSS) and the Geological Survey of Canada (GSC).

Within the SMRS sector, the Canada Centre for Mapping (CCM) in Ottawa, is responsible for the Canadian topographic mapping program. Reconnaissance scale mapping at 1:250 000 scale, comprising some 918 maps, is now complete and are at various stages of revision. Resource scale mapping at 1:50 000 scale is 85% complete. Some of the 12 922 maps comprising this series are in the revision cycle and most of the unmapped regions are in northern Canada.

The Canada Centre for Surveying (CCS) is responsible for providing a precise ground position referencing system for Canada. The survey framework of latitudes and longitudes is to be complete by the end of 1989. The Legal Surveys Division manages and regulates all surveys of Canada Lands within the country. The International Boundary Commission maintains and regulates the land and water boundary between Canada and the United States.

The Canada Centre for Mapping (CCM) is responsible for the establishment management and update of the

National Digital Topographic Database (NDTDB). The availability of digital data from this database is a high priority activity within the CCM, in order to provide base data for support of emerging GISs. The CCM is also responsible for the formulation and maintenance of national mapping standards. The plan is to provide national digital topographic coverage by automatic digitizing of 1:250 000 map graphics by September,1989 and to have this data structured by 1991.

The Canada Centre for Geomatics (CCG) was recently officially opened in Sherbrooke, Quebec. The CCG shares the responsibility for the topographic mapping program with the CCM. The CCG is a high technology centre that is developing data systems to support the NDTDB and is producing topographic maps for eastern Canada.

The Geographical Services Division (GSD) provides aeronautical charts and the National Atlas of Canada. The aeronautical chart production is done on a 28 or 56 day revision cycle according to international standards set by the International Civil Aviation Organization (ICAO) of the United Nations. The National Atlas of Canada program provides maps related to the physical environment, socio-economic geography, natural resources and the historical development of Canada. GSD also maintains names of geographic features and populated places in the National Digital Toponymic Database.

The Canada Centre for Remote Sensing (CCRS) acquires and disseminates earth observations obtained from satellite and aircraft sensing systems. Satellite data from the Landsat Multi-Spectral Scanner (MSS), the Landsat Thematic Mapper TM), the National Oceanographic and Atmospheric Administration (NOAA) satellite, the French Systeme Pour l'Observation de la Terre (SPOT) satellite among others, is routinely available. Aircraft sensor data may be obtained through special arrangements.

The Cartographic Information and Distribution Centre (CIDC) makes available the cartographic data collected and compiled by the other divisions within the SMRS sector. The topographical and geographical maps and the aeronautical charts are sold nationally and internationally. Custom reproductions of aerial photography and satellite imagery are made available through the National Air Photo Library.

The Geographic Information Systems Division (GISD) was recently formed within the office of the Assistant Deputy Minister of the SMRS Sector of EMR, to develop and maintain national standards for GIS in Canada. In addition the GISD is to promote and coordinate GIS activities within government organizations to avoid duplication of effort and to share data. Also the GISD will help coordinate Research and Development activities within the federal government, industry and academia. GIS technology transfer to the private sector will be a priority for this new division.

The Geological Survey of Canada (GSC) is responsible for the production of surficial and bedrock geological maps and regional geophysical and geochemical maps for Canada. The GSC maps are primarily paper products. Numerous aeromagnetic maps, radiometric data maps, various gravity maps and bathymetric data maps are produced annually for various parts of Canada.

FISHERIES AND OCEANS

The Canadian Hydrographic Service (CHS) is responsible for the production and maintenance of nautical charts and related publications to meet the requirements of the fishing industry, commercial mariners, recreational boaters and other government agencies. CHS has been using computer-assisted compilation for chart production and has been demonstrating the use of electronic charting for distribution of nautical information. In addition CHS has been involved in the production of bathymetric maps on a national scale.

NATIONAL DEFENSE

The Directorate of Cartography within DND is responsible for the provision of maps, charts and geographic support to DND and the Canadian Forces. The military cartographic activities have included conventional chart and map production, digital terrain elevation data collection and terrain analysis programs. DND performs some activities that could be done elsewhere, but are not, due to security, urgency or uniqueness requirements. DND is providing several internal services using digital capabilities and products. DND continues to provide additional training for its cartographic personnel to allow them to keep abreast of the latest available technologies.

ENVIRONMENT CANADA

Perhaps the most famous geographic information system, the Canada Geographic Information System (CGIS) resides in Environment Canada. Following a reorganization, the CGIS is now part of the Environmental Information System (EIS). The system contains a database which provides information on land capability for agriculture, forestry, wildlife, outdoor recreation and sport fishing. A complete range of services from data capture through store and display of geographic information are available from the Environmental Information Systems Division.

The Atmospheric Environment Service (AES) reports the weather of Canada, provides weather forecasts, issues severe weather warnings, provides special weather related services and provides information relating to ice and iceberg conditions for the oceans and coastal areas of Canada. AES produces several atlases relating to rainfall, ice and climatical conditions for various regions.

STATISTICS CANADA

Statistics Canada (STC) provides statistics related to Canada's census of population and housing, agriculture and other statistical surveys. STC provides the information collected in cartographic form either as paper maps or in digital format. Digital products include boundary files (municipalities, counties and census tracts etc.), street network files, postal code information and a range of census statistical information. STC is active in promoting the use of digital geomatics data.

AGRICULTURE CANADA

The Land Resource Research Centre of Agriculture Canada (AGCAN) is responsible for research into the location, characteristics, quality, use determination and improvement of Canada's soils. The Canadian Soil Information System (CanSIS) has been developed to assist in the soil mapping activity. A national map series relating to soil landscapes and soil degradation (including wind and water erosion, salinity, acidification and compaction) are being produced. More than 900 maps have been digitized into the CanSIS system.

THE INTER-AGENCY COMMITTEE ON GEOMATICS

The Inter-Agency Committee on Geomatics (IACG) has been formed to encourage coordination of federal government activities as they relate to spatially referenced information. The major aims of the IACG are to:

1. encourage the shared development and exchange of geomatics data.
2. document and disseminate information about geomatics activities within the federal government.
3. cooperate in the collection, development of databases and dissemination of geomatics data.
4. provide consultation on research and education programs.

Several meetings of the IACG have taken place and an IACG Newsletter is being published. A steering committee of senior departmental executives has been formed to provide input and direction for the IACG. Several technical working groups have been set up to coordinate activities relating to research requirements, communications and networking, standards, data models, government databases and user needs. All of these working groups have met and have agreed upon tasks to pursue.

One of the tasks of the government databases working group is to perform a comprehensive survey of the archived and current geomatics data holdings within the federal government. This survey will be performed in the government fiscal year 1989/1990. The results will be compiled, published and distributed in a manner that will give the report wide public accessibility.

GEOGRAPHIC INFORMATION TECHNOLOGY DEVELOPMENT PROGRAM

The Department of Energy, Mines and Resources has signed Memorandums of Understanding (MOUs) with all the provinces, with industry and with a professional association in order to express and record each agencies desire to cooperate in enhancing the use of GIS data and technology.

Under the terms of the agreements with the provincial agencies, the following issues will be addressed:

1. Common standards for geographic information systems will be established.
2. Information, expertise and personnel will be exchanged between the two levels of government.
3. Both governments will help private industry market geographical information systems and related products at home and abroad.
4. Both levels of government will enter into joint ventures, cost-shared arrangements and contracts.

The federal government has agreed to match provincial funding for agreed upon projects. The current total funding level, over a 5 year period, is $16 million, of which $8 million will be allocated from EMR and matched by the respective provinces as agreed-upon projects are assigned across the country.

The former Canadian Association of Aerial Surveyors (CAAS) has been renamed to the Geomatics Industry Association of Canada (GIAC). This national organization represents companies that provide services in the geomatics field. GIAC is engaged in assisting in the expansion of export markets, in the development of a data base of Canadian Geomatics industry capabilities, in the production of improved media for the industry, and to negotiate with the government to modify procurement practices to help develop industrial capability and competitiveness. An MOU has been signed between the federal government and GIAC to assist in these endeavors. An MOU with the Canadian Institute of Surveying and Mapping (CISM) has also been signed.

SUMMARY

The Canadian federal government has a number of geomatics data bases that have been developed over the years. Historically this data has been stored in the form of paper maps and related publications. However, with the advent of larger and faster computing capabilities, the government is moving to more provision of digital data. This data is the cornerstone of geographic information systems. The Department of Energy, Mines and Resources is taking a leading role in promoting the use of GIS data and technology. A partnership with the provinces, the Canadian industry and academia has been agreed upon.

The fostering of a strong and competitive private sector has been a primary element in the formation of a new national strategy for GIS. Money and resources have been committed to stimulate the government and industrial agencies. Although this is a modest first step, it is hoped that these initial activities will keep Canada in the forefront in this technology for years to come.

FORESTRY, REMOTE SENSING AND WORKSTATIONS: PRESENT STATE AND FUTURE TRENDS

W. M. Johnstone and S.H. Paine

MacDonald Dettwiler and Associates, Ltd.
Richmond, British Columbia

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

There is an increasing demand for digital remotely sensed data to be used in the creation and maintenance of geographic databases. Vector data from the GIS is displayed with the raster satellite imagery while maintaining full image processing capabilities. The exploitation of this technology will provide more cost-effective methods for creating and maintaining forestry GIS databases.

1. SUMMARY

The purpose of this paper is to foster discussion. It presents a view of the forest industry from the remote sensing perspective. Two topics are discussed:

- forestry and remote sensing;
- present state and future advances in remote sensing and workstation technology.

2. FORESTRY AND REMOTE SENSING

The information needs of the forestry industry vary according to the management level utilizing the data. The various levels have different needs which can be summarized by the geographic areas involved, the form of the data and the frequency of access.

The highest level of forest management is involved in planning, strategy and policy decisions for the entire forest area. This level has the lowest data utilization frequency and uses the data in tabular statistical form.

The next level deals with management of specific regions to carry out the policy directives. This level uses tabular and statistical data in conjunction with map information on a fairly regular basis to perform modelling of the resource.

The lowest level is a local area management with very site-specific information that has a high data input/output frequency. The information at this level is very spatially oriented and uses map products with associated statistics.

2.1 A View of the Forestry Management Process

One method of describing the forestry management process is to divide it into three steps: measurement, information acquisition and information utilization:

measurement	the process of measuring features of interest on the ground (e.g. ground surveying, acquiring airphoto, satellite remote sensing).
acquisition	the process of taking measured data and manipulating it until it is in a form that it can be utilized (e.g. ground surveying, digital correction of satellite imagery, digitizing of paper maps);
utilization	the process of using the acquired geographic information to solve problems (e.g. decision support, forecasting, modelling).

Implicit in this process is the assumption that a data management system (a paper system and/or digital database) exists to facilitate storage and utilization.

The reason for making this distinction becomes clear when we realize that typically 60% or more of operating costs go into the generation of the geographic information database. More time is spent moving the data around, changing formats, etc. before any real work is done.

2.2 Forestry Management Issues

Four issues become apparent once this distinction is made: currency of the database, timeliness of the data, affordability to acquire the information, accuracy of the information.

3. REMOTE SENSING AND PROCESSING TECHNOLOGY

3.1 Current State

We describe the current state in terms of measurement systems, processing technologies and capabilities.

Measurement systems include: airborne sensors (airphoto, thermal scanners, multispectral scanners, imaging radars), and satellite sensors (Landsat, SPOT, meteorological). Current processing technologies include: image processing, GIS, spatial analysis, spatial and relational databases.

These measurement systems and processing technologies provide the following capabilities:

- hardcopy generation for photointerpretation;
- generation of thematic maps;
- extraction of DEMs from SPOT using digital techniques;
- digital stereodisplay of SPOT imagery;
- rudimentary spatial modelling;
- simultaneous display and processing of imagery and graphics for base map feature extraction.

Capabilities such as the last one listed above are generally limited to visual interpretation on the screen assisted by image processing techniques to enhance features. A number of automated approaches have been demonstrated, but none are currently operational.

3.2 Future of Remote Sensing and Processing Technology

A number of new satellite and airborne sensors have begun operation or will begin operation in the mid-1990's. Satellites include ERS-1 (Europe), Indian Remote Sensing Satellite-1 (IRS-1), Japanese Earth Resources Satellite-1 (JERS-1) and Radarsat (Canada). Airborne sensors include multispectral scanners and airborne imaging spectrometers.

Processing technology will also have advanced with the advent of object-oriented databases. The benefit to come will be the greater flexibility in customizing the system to meet unique requirements, and flexibility in making modifications in the future. Further advances in workstation display and user interaction technology will also provide foresters with better tools to utilize the acquired information.

Potential new processing capabilities include: digital elevation extraction from digital airborne sensors and airphoto data, and databases which handle true three-dimensional datasets in ONE database. The goal is to move into a world where issues such as imagery versus graphics are mere technical details rather than important issues for the user.

4. CONCLUSION

MacDonald Dettwiler, as a traditional Remote Sensing company, is involved in many aspects of the industry. We have built earth resources ground stations, airborne radars, an airborne scanner with specific forestry applications (MEIS), and geographic data acquisition workstations. We believe that a significant portion of the costs to solve forestry management problems will be spent on acquiring and maintaining geographic information. Our mission is to provide solutions which reduce these costs so that forest management can be made more affordable.

MAKING GIS WORK IN FOREST MANAGEMENT

Glen A. Jordan, RPF

Faculty of Forestry
University of New Brunswick
Fredericton,
New Brunswick E3B 6C2

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

It is not particularly difficult, in today's climate, to justify acquisition of a GIS in most forestry organizations, since the technology offers great upside potential and apparently very little downside risk as an aid in forest management decision making. However, the processes of acquiring and implementing a GIS are far more difficult rows to hoe. Although there is great opportunity, there is also great risk of error and waste of large amounts of money and time. This paper exposes those considerations, issues and questions most crucial to the successful acquisition and implementation of a GIS for forest management.

Keywords: forest management, GIS, implementation, pitfalls

INTRODUCTION

Forest management is held out as the solution to a future shortfall in Canada's forest growing stock and geographic information systems (GIS) are currently the darlings of the forestry profession. That the convergence of the two on the forestry scene is more than coincidence could be debated but, that design and implementation of the former could be greatly facilitated by implementation of the latter is fact. However, both are relatively new commodities and as a result not only their implementation but their relationship as well are poorly understood. This paper will concentrate on geographic information systems and their implementation for forest management decision making.

A reasonable starting point would seem to be with definitions of forest management and geographic information systems. Forest management involves the design and implementation of a plan of actions (and inactions), sequenced over time and geographic space in order to control the future forest in terms of its, structure (distribution of the forest over age classes and geographic distribution of age classes) and thus a desired flow of benefits. A GIS, on the other hand, is computer-based technology characterized by specific hardware and software that permits the simultaneous storage, management and analysis of data along with its geographic location. It is, in other words, a spatial database management system.

It is not difficult to make a case for GIS technology as the basis of an information system for decision support in forest management. Forest management has both temporal and spatial dimensions involving decisions of not only what, how much and when, but also where. Since a GIS is unique among information systems in that it accommodates spatial data, thus permitting the management of resources over time and space, it seems logical that GIS technology should form the basis of a decision support system in forest management. There is very little risk that making a decision to implement a GIS will be a wrong one; in fact, it's fair to say that forest companies who ignore GIS technology risk being taken over by competitors who take advantage of it. However, the real risk, of which there is plenty, arises in attempting to achieve a successful GIS implementation. In addition to meeting specific organizational objectives, a successful GIS implementation will be one characterized by at least:

(i) being on schedule,
(ii) being within budget,
(iii) giving reasonable response times to user queries,
(iv) meeting or exceeding user and management expectations,
(v) providing forest management decision support at intended levels of application (policy, management and/or operating), and
(vi) obtaining support of key personnel - managers, users and technocrats.

GIS IMPLEMENTATION PLANNING

The approach to implementing a GIS should not really be any different from the generally accepted approach to designing and implementing forest management. Clearly and quantitatively stated objectives (including intermediate milestones) must be present and the best possible plan of action for reaching those objectives must be identified. The success of a GIS implementation will be measured, like forest management, in terms of its achievements and not in terms of good intentions and valiant efforts (Wellar 1982).

The only way that success can be gauged is for achievements to be measured against originally identified milestones and objectives. Generally, a GIS implementation plan must address the following technical, financial, and institutional considerations:

(i) system acquisition tactics and costs,
(ii) data requirements and costs,
(iii) database design,
(iv) initial data loading tactics and costs,
(v) system installation tactics, timetable and costs,
(vi) system life cycle and replacement costs,
(vii) day-to-day operating procedures and costs,

(viii) new staffing requirements and costs,
(ix) user training and costs, and
(x) application development and costs.

The mere presence of an implementation plan, however, does not guarantee success. There is ample evidence that GIS implementation planning is fraught with many pitfalls. Keeping in mind the aforementioned planning considerations, this paper will expose those technical, institutional and financial pitfalls that are most likely to contribute to the failure of a GIS implementation for forest management decision making. The pitfalls have been gathered from several sources; including, journal articles, conference and symposium proceedings, personal experience and from conversations with experienced individuals.

GIS IMPLEMENTATION PLANNING PITFALLS

Pitfall #1: Failure to Identify the Users

Ultimately users determine what data a system should maintain, how it should process the data and the form that it should be presented in for decision making. It would seem to be obvious then that users needs should receive due attention in any implementation plan. However, it's a focus that's made illusive by the nature of forest management decision making. Users in a forest management environment are spread over three different levels of decision making: policy, management, and operations. Information requirements are very different at each of these levels. The trick," . . . is to design and implement an information system that maintains information consistency across all levels of decision making, while still providing each level with information at the scope and resolution that it requires,"(Baskerville 1988). This is not to say that all GIS implementations must serve all three levels of decision making to be successful.

However, a failure to recognize the hierarchical nature of forest management decision making and differing information needs will result in a GIS implementation that lacks user focus and serves neither policy, management nor operations decision making.

It is, therefore, crucially important to know who the intended users of a GIS are to be designers of policy, management and/or operations.

Pitfall #2: Failure to Involve Managers and Users, as well as Technocrats

A GIS will impact significantly on an organization. In particular, it will introduce new information gathering procedures, new processing requirements, new output products, new staff responsibilities and, perhaps, new approaches to forest management decision making itself. People in an organization will be affected! A basic management tenant introduced to students of management early in their studies is that participation is a key to success. If the people in an organization that will be affected by a new initiative are not involved in its design, their crucial input will be missed, their support lost and failure of project implementation ensured.

It is, therefore, important that GIS implementation involve representatives from various levels within an organization: decision makers, managers, technocrats and, most importantly, forest managers (Baskerville 1988)(Newton 1986).

Pitfall #3: Failure to Match GIS Capability and Needs

Today, unlike the situation just five years ago, GIS hardware and software choices are many and varied. There are presently dozens of systems being marketed in North America. They cover the cost/performance spectrum; ranging from microcomputer configurations of relatively low cost ($15,000) and performance, up to minicomputer configurations of much greater cost ($250,000+) and performance. A buyer is presented with a significant challenge making the right choice. The right choice will be the GIS that provides the needed performance no more, no less for the minimum investment (Burrough 1986).

GIS implementation success is particularly sensitive to the right hardware and software choices. Specifically, selected hardware and software must satisfy capacity, i.e. specific data needs and volumes, and function, i.e.

specific data processing needs associated with anticipated application development. Identification of capacity and functional needs can be difficult and even frustrating but, failure to do so will result in one of two outcomes. In the worst case the selected GIS will never get past the data loading stage of its implementation. In the best case, the GIS implementation will be retarded in its evolution and fail, or be slow, to achieve its intended place as a forest management decision support tool (Crain 1983).

It is, therefore, important for a GIS implementation plan to initially specify a requirements and assessment study to guide GIS selection.

Pitfall #4: Failure to Identify Total Costs
GIS acquisition cost is relatively easy to identify; involving essentially the initial purchase price of GIS hardware and software. Although seemingly large, it will in fact represent a very small fraction of the total cost of implementing a GIS. Significant, ongoing costs will include hardware and software maintenance, system infrastructure construction, staffing, system administration, initial data loading, subsequent data updating, system programming, eventual system hardware replacement, and perhaps consulting fees. A failure to identify all costs, up front, will result in the need to repeatedly requisition additional unexpected funding. An organization's financial planners are intolerant of such surprises (Brown 1986).

It is, therefore, important that a GIS implementation plan incorporate accurate, relatively long-term, cost projections for all aspects of GIS operation, if project credibility is to be maintained and GIS implementation allowed to evolve fully.

Pitfall #5: Failure to Conduct a Pilot Study
A GIS implementation plan must deal with many technical and administrative issues and their related cost impacts. Three of the most crucial issues, in terms of failure sensitivity, are database design, data loading and maintenance procedures, and day-to-day operating logistics. Resolution of database design issues, data capture tactics and costs, data needs and storage amounts, processing needs and times, manpower time and costs, and administrative logistics will require the collection of detailed information. The time-honoured pilot study has considerable merit in this regard. The idea is to gather detailed observations from a test of sufficient duration, size and complexity to be representative of operational conditions. Failure to do so will guarantee implementation foul-ups.

It is, therefore, important in a GIS implementation plan to spell out design specifications as well as time and cost forecasts.

Pitfall #6: Giving GIS Implementation Responsibility to the DP Department
Spatial data handling is not even close to running a payroll system or, even a forest inventory of the past; it has special problems which depend upon a unique body of knowledge for solution(Marble 1982). Although an organization's Data Processing Department will ultimately provide some technical staff, the GIS implementation team is best staffed, at least at the top, by non-data processing types. This would include a manager who falls somewhere in the cracks between forest manager and GIS analyst. To do otherwise will ensure failure (Brown 1986).

It is, therefore, important that GIS implementation not be managed by an organization's Data Processing Department.

Pitfall #7: Failure to Consider Technology Transfer
As stated earlier, spatial data handling represents an unique body of knowledge with its own problems and solutions. GIS technology is also relatively new and it is unlikely that personnel within an organization will have a great deal of understanding and appreciation of it. A GIS implementation plan should, logically, identify and address training needs on two fronts: (i)targeted users, i.e. forest managers, and (ii) technocrats. The education of either group is not a one-shot, quick and dirty affair. Spatial data handling is not only an unique body of knowledge, it is also a very large and complex one. While failure to educate in-house technicians will merely necessitate hiring new college or university educated individuals (likely in any event), failure to educate targeted users will ensure that a GIS implementation becomes an end in itself; failing to generate applications characteristic of a forest management decision support system.

It is, therefore, important that a GIS implementation plan budget time and money for the education and training of the principal users of the technology the forest managers. To a lesser extent, training of in-house technicians is important as well.

SUMMARY

While it may not be difficult to justify the acquisition of a GIS for support of forest management decision making, successful implementation requires great care and attention. To have a chance at success, GIS implementation must be a controlled undertaking; planned to serve the design and implementation of forest management. A plan's ultimate success, regardless of how it is decided to measure it, will depend upon the degree to which it addresses, in as comprehensive and quantitative manner as possible, an array of technical, financial and institutional questions while avoiding some known pitfalls and oversights.

REFERENCES

Baskerville, G. and T. Moore. 1988. **Forest Information Systems that Really Work.** For. Chron. 64(2): 136-140.

Brown, C. 1986. **Implementing a Geographic Information System: What Makes a New Site a Success? Proceedings of Geographic Information Systems Workshop**. Atlanta, American Society for Photogrammetry and Remote Sensing.

Burrough, P. A. 1986. **Principles of Geographical Information Systems for Land Resources Assessment. Monograms on Soil and Resources Survey No 12.** Oxford, Oxford University Press.

Crain, I. K. and C. L. MacDonald. 1983. **From Land Inventory to Land Management: The Evolution of an Operational GIS. Automated Cartography: International Perspectives on Achievements and Challenges.** Hull, The Steering Committee, Sixth International Symposium on Automated Cartography.

Marble, D. 1982. **Does the Purchase of Expensive Computer Systems Help the Problem or Create New Ones? Computer Assisted Cartography and Geographic Information Processing Hope and Realism**. Ottawa, Canadian Cartographic Association, Department of Geography, University of Ottawa.

Newton, C. 1986. **Management Impact of Geographic Information Systems. Proceedings of Geographic Information Systems Workshop**. Atlanta, American Society for Photogrammetry and Remote Sensing.

Wellar, B. 1982. **Computer-Assisted Information Systems: Purchasing and Development Pitfalls. Computer Assisted Cartography and Geographic Information Processing Hope and Realism.** Ottawa, Canadian Cartographic Association, Department of Geography, University of Ottawa.

APPLICATION OF GIS AT THE DIVISIONAL LEVEL

Geographic Information Systems

or

Garbage Induction Systems?

Jack Lavis

Superintendent, Forestry and Logging
MacMillan Bloedel Ltd.
Cowichan Logging Division
PO Box 630, Chemainus
British Columbia, V0R 1K0

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

MacMillan Bloedel acquired their first GIS in 1980. The system has been primarily used for forest inventory and fibre supply analysis at the corporate level. Over the past year the Cowichan logging division of MacMillan Bloedel has been using a microcomputer-based GIS for silviculture record-keeping and development planning. The system is linked to the corporate GIS. This paper will discuss the division's experience with GIS and provide some insight into how a GIS might be justified at the operational level.

INTRODUCTION

One of the most important pieces of information for the foresters and engineers at the Division is the inventory. Three factors which make the inventory workable are:

- reliability
- date last revised
- ease of access

In our particular case in the past all three items above were serious problems.

a) Reliability - last cruise conducted on our second growth which represented 65% of our holdings was 1969.

b) Date last revised - normally our inventories were three to four years behind with respect to current information, (logging, roads, planting, etc.).

c) Ease of access - all queries were made through our Inventory Section in Nanaimo and handled on a "time available" situation. Therefore very little was asked for.

Our inventory presently breaks down as follows:

Mature 101+yrs	Immature 1-100 yrs	Deciduous Alder/Maple	N.S.R.	N.P. rock/swamp/ alpine	N.S.F. farm/roads
12,181	46,186	2,388	1,603	6,027	3,023
				TOTAL	71,408 ha

How did we end up with our GIS and what do we intend to do with it?

THE BACKGROUND

So how did we proceed to get a good "GIS" in place with the following points in mind:

- reliable, accurate information
- current updated inventory
- compatible software/hardware with our Nanaimo section
- user friendly

During 1985 our company decided to expand on the "Intergraph System" it was using as a computer aided mapping system to a graphics information system. The two systems looked at were:

- update of Intergraph
- E.S.R.I.

Early in 1986 our company made the decision to go with the E.S.R.I. geographic information system. We then decided to become totally compatible with our Nanaimo end and also work towards being self sufficient.

THE PLAN

To eventually end up where we would feel we had a good workable system required the following:

ITEM	CORPORATE COST	DIVISIONAL COST
- Hardware/Software	$ 35,675	
- New updated Second Growth Inventory	325,598	
- Updated 1-20 year old inventory	48,000	
- Totally updated Div. Inventory		
Dec. 31, 1988		$149,000
- Software Programming	8,000	
- Digitizing 1:5000 topog. maps	6,000	
- Digitizing Forestry area openings	3,500	
	$ 426,773	$149,000

If you have any knowledge of being in the forestry department at a logging division you will understand what the reaction would be from your manager coming forward with the above request.

Therefore we put together the following time frame that would see us totally operational by August 1989 and add to the data base during 1990.

ITEM	COST	TIMING
Namtec ATP Computer (lmb RAM) (1.2 floppy)	2,999.00	Feb/87
40 meg hard drive	1,760.00	Feb/87
80.287 math co-processor	495.00	Feb/87
Tecmar EGA Master	495.00	Feb/87
Datatrain DC350 Monitor	729.00	Feb/87
Roland PR 1012 Printer	379.00	Feb/87
Tektronix 4696 Colour Copier	3,153.00	May/87
Arc Info "Starter Kit"	3,600.00	Feb/88
Parallel Switch - Printers	100.00	June/88
Arc Plot software Package	1,800.00	June/88
Updated Second Growth Inventory	325,598.00	Jan-Dec 88
150 Meg. Hard Drive	2,350.00	Jan/89
Digitizer (Edit Maps)	4,000.00	Mar/89
Plotter "Calcomp 1023"	8,415.00	Mar/89
Arc Edit Overlay	5,400.00	Apr/89
Updated Divisional Inventory	149,000.00	Aug/89
Software Programming (User interface Menus)	8,000.00	Jun-Dec 89
Updated 1-20 Year Inventory	48,000.00	1986/87/88/89
Digitize 1:5000 topog. maps	6,000.00	Mar-Jun 90
Digitize Forestry Openings	3,500.00	Jul-Sep 90
THE COST	$575,773.00	

THE USE

One of the most important uses of the GIS will be to analyze the inventory of our operation to assist in:

- logging planning (species, markets, time of year, systems)
- reforestation
- spacing
- thinning
- fertilization
- assessments
- site preparation
- brush control
- etc.

We will also totally update our inventory with current information every three to four months depending upon work load.

EXAMPLES

I have several slides and mapsheets to show to you some of the uses we will be getting from our system.

- Specific mapsheets can be queried to illustrate spaced areas and parameters can be given to highlight areas of potential spacing.
- Specific parameters can be fed in on a mapsheet basis to interrogate thinning potentials.
- Specific areas can be blown up for better viewing.
- N.S.R. areas can be highlighted and printed on forest cover maps to facilitate planting and stocking assessments.
- Old growth stands can be queried for high value species (Cypress), and a map produced to facilitate ground reconnaissance

SUMMARY

There are several GI Systems on the market. Each system has its own specific process of integrating forestry data into a management package. The decision as to which system to use is sometimes determined by cost, compatibility with other company systems etc.

We are very excited at the prospect of working with and growing with our GIS management package. We feel our data base is accurate and will allow us to feel confident with any analysis conducted. The system will definitely save time and all new additions (layers) will be analyzed as to cost/benefit.

SO YOU BOUGHT A GIS - NOW WHAT?

Allan G. Levinsohn

A.G. Levinsohn Consulting Inc.
Suite 1560, 10303 Jasper Avenue
Edmonton, Alberta
(403) 428-7773

GIS'89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Many organizations begin implementation of a geographic information system (GIS) with the selection of GIS hardware and software. The necessary planning and design required for successful implementation is rushed or never performed. As a consequence, many technical, institutional and personnel issues are not dealt with and the systems fail to live up to expectations. Adequate experience with GIS implementation exists to identify aspects of project planning and organization that can help to ensure successful GIS implementation. These include comprehensive project planning, appropriate staffing and training, formalized application selection and design techniques and executive commitment to system implementation.

INTRODUCTION

Most automated information system projects do not fail because of a lack of technology or technical failures. They fail because of poor project planning and management.

The cost of the project is underestimated losing management support prior to completion, or inadequate time is allocated for staff training and the projected productivity is not achieved, or worse, there never was a project plan. Applications for use of the system were not selected and designed, they just happened.

The selection of geographic information system (GIS) hardware and software should occur toward the end of the implementation process, but more often then not, it is the starting point for GIS implementation. Once the system is in-house, the pressure to produce something is on. Planning and organizational issues become dealt with in an ad-hoc, reactive manner rather than in a well conceived proactive plan. How often is the phrase "lets quit talking about it and get on with it" heard? This statement may result from ignorance of the "pitfalls" in implementing automated information systems, past frustrations with previous poorly organized planning exercises, or unrealistic commitments made to management in order to sell them on the GIS. Often it is said that "we don't have time to go through all this planning, we have to have this system implemented right away." The importance of effective planning increases with the pressure for speedy delivery of the completed system. It is when a truly tight schedule must be met that we must learn to do work less of the time and to plan more of the time.

Clearly the size and scope of the system governs the size of the project, the amount of staff, and the complexity of the plan. However, unless you will forever be the only user of the system, unless you never plan to leave, and unless no-one else will ever be interested in the outputs of your system; at some point your work will have to be integrated with that of others. How well that occurs is a function of how well thought-out the process for accomplishing integration was.

This paper presents some aspects of planning and organization management essential for successful GIS implementation.

BACKGROUND

In a recent study involving case histories for about 500 system development projects since 1977 it was found that fifteen percent of studied projects were aborted in progress or delivered products that were never used (DeMarco and Lister, 1987). Twenty-five percent of major projects (lasting 25 work-years or more) failed to be completed (Jones, 1981). In the overwhelming number of these projects there were no technological issues to explain the failures. It was found that most failures could be attributed to the sociology of the project team; "the major problems of our work are not so much technological as sociological in nature" (DeMarco and Lister, 1987).

Examples of sociological and institutional problems that may be encountered are: communication problems during system design, resistance to technological change from perceived personal threats to job or power, lack of executive commitment, under estimates of required resources, over estimates of returns, inadequate integration of the system with business functions, and a lack of will to make the institutional changes required to derive cost-effectiveness from the system.

Even with adequate planning significant problems can result from poor communication between the end-user and the system designer as to what is required and what can be delivered. The process of design and implementation often changes the user's perception of his needs. What was asked for may not be what is needed after the system has been implemented. Many processes that support decisions, particularly senior level ones, are based on the decision makers mental image of the problem relying on information gathered through a variety of personal experiences. Such a process is not explicit or easily quantifiable and is difficult to support with an automated information system.

Implementation of new technology leads to changes in the organization. Systems that have been designed to meet needs specific to the current operations of an organization may not meet the needs of the changed organization.

Most existing functions have been based on techniques and information that could be provided prior to the introduction of automated systems. The introduction of automated techniques changes the scope of what is feasible and many old processes are reconceptualized within the new bounds of what is feasible. Systems designed too closely to current procedures may prove to be inadequate within the new realms of what is feasible.

Many early system development projects promised more than could be reasonably delivered, or cost significantly more than planned. Often management has become appropriately sceptical of new system projects and claims of enormous gains in efficiency and effectiveness.

Project planning cannot eliminate these problems but it can develop specific strategies for dealing with them and reducing their impact on the success of the GIS.

PROJECT PLANNING

Effective project planning begins with well defined goals and objectives. Only a clear definition of mission and purpose of the business makes possible clear and realistic business objectives (Drucker, 1973). The business objectives of the company are the foundation for strategies, priorities, plans and work assignments. Managerial jobs, organizational structure and the company's business strategy are all governed by the business objectives. An automated information systems strategy should support the needs of the organization as defined by its business objectives. The information systems strategy identifies what business activities will be affected by implementation of the strategy and how they will be affected.

Ideally, GIS planning is performed within the framework of an overall corporate automated information systems strategy of which GIS only forms a part. The GIS should be designed to support related business objectives and the implementation plan should identify the means for integrating its use into the overall stream of day-to-day business activities.

When the purpose of the GIS has been established, implementation planning can proceed. There are many structured approaches for design and implementation. Regardless of the approach used, system development can be considered to occur in four phases:

Conception	the process that leads to the initiation of the GIS project. The political, administrative and monetary commitments are obtained and the general system philosophy and scope are determined.
Design	the general philosophy developed during the first phase is translated into a precise definition of the system, within the scope and monetary constraints identified in the conception phase.
Implementation	the process of constructing the design created in the second phase.
Operation and Maintenance	making the system available to users and satisfying the objectives identified during conception. It includes day-to-day technical management, enhancements, and performance evaluation.

The design and implementation phases can be further subdivided into: conceptual design, strategic planning, application selection and design, data base design, system acquisition, installation and training, and data capture/ conversion. Often the tasks are not as distinct as presented here, and frequently early tasks are revisited during actual implementation.

The principal objective of the process is to build a technically successful system that is utilized by the end-user and that satisfies the organizational objectives. Successful implementation is in part measured by the long term

usefulness of the system. The completed system should be capable of being modified to accommodate growth and organizational change.

Structured techniques for system design and implementation are well defined in a considerable number of works, including that of Booth (1983), Martin and McClure (1985) and Yourdon (1986), and will not be dealt with in this paper. However, a set of generalized tasks can be derived from these to serve as context for the discussion in the next section of this paper.

The significant data that is used to support decision making at various levels such as the TFL, the compartment, the stand and the cut-block must be determined. To organize the data it is necessary to determine the "procedural context" of the data. That is, how the data are used in the company - who collects it, analyses it and uses it in making decisions. The sources of the data can then be determined. Does the data originate in company, or is it received from a government department, and so forth. Related technical issues must also be dealt with - such as content, requirements for special formats, timeliness, and exchange standards.

Within this context it is possible to define appropriate roles and responsibilities for data collection and maintenance, the setting of standards and policies and for resolving issues related to processing and dissemination. The result should be an understanding of current information use in the company. This must then be adjusted to account for planned changes identified in the strategic plan, above.

With an understanding of information use in hand, it is possible to determine the appropriate type and amount of technology to support the company's information handling requirements. The component technologies needed for each part of the identified process can be determined. Other issues that must be dealt with at the same time are: integration of component technologies, location of the equipment (degree of decentralization), responsibility for management (maintenance, etc.), and the "upgrade path" for the system (how to accommodate new needs).

At this point, institutional impact issues should be revisited. The requirements for training, new staff, changes to organization structure and procedures should be reviewed and a plan for change management determined.

If the preceding process is performed well, realistic costs and schedules for implementation can be determined. It is also possible to predict what changes are likely to occur and what will need to be done to deal with or take advantage of them.

PROJECT ORGANIZATION

The previous section dealt with the planning process. The intent of this section is to provide some general points with respect to the administration of GIS implementation and operation.

Some of the issues raised may seem to be obvious and the resolution of them natural. However, first-hand and documented experience in system development have shown these issues to be major causes of system failure. The following paragraphs present some of the key issues in ensuring successful system implementation.

Executive commitment for the project is essential to ensure that adequate resources are provided and that necessary policy issues will be dealt with. Management must be well informed by the project team at the outset of the phases of development and the amount of time and effort required to develop the system. An honest assessment and characterization of the project at the outset will prevent many later problems.

A high degree of end-user involvement in all aspects of system development builds commitment to the system, establishes credibility of design, and ensures the system will be used and meet user's needs.

The use of technical consultants for analysis and design tasks will speed implementation by shortening learning curves and provide needed on-site experience prior to company staff having attained it.

Contracting-out large easily defined tasks (e.g. large data conversion efforts) that draw heavily on internal resources, while producing little in the way of user satisfaction, or technical tasks that require sophisticated expertise for short periods, will reduce pressure on company staff and accelerate system implemenation.

A multi-year system implementation plan should identify the requirements, resources, and responsibilties of departments and individuals involved in the project. The plan should identify the operational goals, objectives and policies; document existing capabilities, define the specific needs; and state the design methodology, and work schedule for the project.

All aspects of the project should be well documented to speed user and new technical staff training, to establish and communicate standards, to eliminate the dependence on individual personalities, and to facilitate staff transfers.

The implementation of new technology provides an opportunity for re-evaluation of organizational structure, mandates and information flows. A properly coordinated project will have the representation and management support necessary to evaluate opportunities for beneficial organizational change. A project committee structure should be established to facilitate the necessary coordination. The number and size of committees and the frequency of meetings will depend on the organization culture of the company and the size of the project.

There should be a senior management committee comprised of the senior managers of departments involved in the system implementation chaired by the CEO or his designate. This committee should review project progress, and set policy and budgets. The head of organizational unit responsible for the GIS implementation reports to this committee.

Complementing the senior management committee should be a project management committee comprised of middle managers or senior professionals of the departments that will be using the GIS, including service departments responsible for accommodation, telecommunications and so forth. This committee monitors progress of the project, reviews recommendations from the project manager, approves expenditures within budget, and ensures adequate cooperation from participating departments. The project manager reports to this committee.

In larger companies and for larger projects it may be beneficial to have one or more end-user working group(s). These are comprised of senior working staff from departments that will be or are planning to implement GIS applications. These can be chaired by the Project Manager. They provide access to the information and data required for application design and implementation, review the application designs and prototypes, and facilitate training and analysis sessions. Such committees are good vehicles for building the end-user involvement and commitment essential for successful system implementation.

Another optional committee, again depending on project size and complexity, is a technical advisory committee. It is comprised of technical staff and consultants. Chaired by the Project Manager, it provides the expertise for system analysis and design, technical direction, and recommendations on necessary standards, procedures and so forth.

It is very important that the group or individual best qualified to deal with a specific issue be allowed to decide. In many instances the roles of each group become confused with disastrous results for the project.

PROJECT STAFFING

A successful self sustaining system requires knowledgable committed staff. Experience with many system implementations has identified several key positions and the associated necessary skills for a successful system. These positions are based on tasks and functions that have to be performed. How many of these positions exist for any project is determined by the size of the project, the volume of work, the extent to which staff have other duties, and the skills of the staff.

Vendor training covers the software operation but does not deal with other equally important functions of a GIS. The following outlines five key positions, and areas of expertise, recommended for implementing and operating a GIS facility. As projects and systems increase in size, these positions may be split to create more specialized positions.

GIS MANAGER

Overall responsibility for the GIS facility rests with a GIS manager. The manager should have a broad understanding of the GIS system, its capabilities, its applications, and the product types which can be generated. The person should ideally have an information systems management background, be skilled in personnel management and possess an understanding of geographic data and its applications. However it is best if the GIS manager is an existing staff member well experienced with the company's functions trained to become familiar with the GIS software. Knowledge of the business is of greater significance than technical computer knowledge, but prior computer system experience will reduce the learning period. The GIS manager is responsible for administration and planning, budgeting and schedules, and coordination of the user community for their geographic information needs.

GIS line management should not be confused with project management. Line management is business management. It involves all aspects of the business including personnel, finances, and ensuring profitability. The line manager views the GIS project as one among many in the company. The project manager's only focus is the successful implementation of the system. Special project management and systems analysis skills are required for success. Project management can be frustrating and the position requires considerable skills in negotiation, inter-personal communication, and past experience in the design and implementation of automated information systems. The project manager must plan what is to happen, obtain agreement, and ensure that what has been planned happens. For these reasons, project management is often contracted out.

GIS SYSTEMS ANALYST

A geographic information system analyst aids users in identifying and defining GIS products to be generated for each application, performs planning of processing steps for GIS applications, directs in-house software training, and performs data base design and organization. The person should have specific knowledge of the selected GIS software and how it can be used, GIS concepts, data base design principles, application design principles, an ability to communicate and plan specific work tasks for data base creation and management, analysis, and product generation, and a good knowledge of the computer operating system.

PROGRAMMER

For successful operation of a GIS it is essential to have a programmer with specific knowledge of the GIS software and how to combine various commands into macros (strings of GIS commands). The person should also have extensive experience with the selected computer operating system including the operating system's command language, graphics drivers and programs.

The principal responsibility of this person is the writing and testing of macros, isolating software problems and debugging the site-specific software. However in smaller installations, this person is often responsible for backups and other general system maintenance as well. The GIS programmer can be an existing staff member with the appropriate computing skills trained to perform the required functions. However, given the time required to become knowledgeable, it will be more cost-effective to hire a programmer, if there is no one in the organization well versed in the operating system and programming languages of the selected hardware.

The programmer may also act as a senior processor generating GIS products. In that case, a knowledge of map projections, scale and other aspects of cartography are required for processing cartographic files for map production. Other duties include managing project directories, performing complex processing functions such as spatial analysis and plot creation.

COMPUTER SYSTEM ADMINISTRATOR

The system administrator must have an understanding of software system directories, organization and use of the computer operating system, the GIS software, other installed peripheral software. Other required knowledge includes: knowledge of on-site hardware, including graphics devices and digitizing tables, and an intimate knowledge of the computer operating system.

This position is responsible for systems management including performing data backups, and installing and maintaining hardware, designing and setting up disk file organization.

The tasks can be performed by the Programmer if he has adequate technical knowledge and if the system is not too large and the development tasks too numerous, as to affect proper system administration. The person for this position is usually best hired, given the large amount of technical knowledge/experience required. It is not practical to train marginal internal staff.

CARTOGRAPHIC TECHNICIAN

This position is responsible for a wide variety of tasks such as photo and map interpretation, drafting, digitizing and mapping requirements for a particular set of applications.

This position can be filled by an existing staff member trained to perform the required functions. The training requirements are not as extensive as for some of the other tasks; about 2 weeks formal training and 1 - 2 months of work experience to become proficient.

To economize, it is possible to hire a cartographic technician who can also perform routine system administration tasks and some programming (especially new macros). The GIS Manager can also perform some system administration tasks, depending on technical expertise and work-load. However, it is essential that the system administration tasks are properly and routinely performed, therefore, although it may be possible to share the work and save on staff, it must be a top priority for the staff responsible - the entire investment in the system depends on it.

For some positions, such as the Programmer and the Cartographic Technician it is useful to have highly experienced help immediately upon installing the system. There are several options for obtaining good technical support. Although good staff are scarce and may be expensive, hiring for a longer term position such as the Cartographic Technician is usually the best approach. Experienced staff can be contracted from a consulting firm to undertake the front-end development and provide in house training of permanent staff. A contract programmer can work on-site for a year or so as part of the purchase agreement with the GIS vendor.

End-user training is usually provided by the GIS software vendor. If possible such training should be taken in stages to permit practice and familiarization prior to proceeding with more complex uses. This is particularly significant for the Cartographic Technician, Programmer and System Administrator.

The system can also be implemented so that most of the user access is through menu driven interfaces to custom applications. This reduces the amount of end-user training required, but increases implementation costs and the need for an experienced programmer at the outset of implementation.

CONCLUSION

In summary don't begin GIS implementation by buying a system, but if you have, take the time to deal with planning and organization issues anyway; only limited success is possible without doing so.

Make sure the following are in place: executive commitment for the project, a multi-year implementation plan based on a comprehensive system design, a staffing and training plan, and an organizational structure that will ensure good communication and support.

REFERENCES

Booth, G. M., 1983. **The Design of Complex Information Systems: Common Sense Methods for Success.** McGraw-Hill, New York, N.Y.

Clapp, James L. 1977. **North American Land Information Systems: an Overview with Recommendations.** Presented at: the XV International Congress of Surveyors, Stockholm, Sweden, June, 1977.

DeMarco, T. and T. Lister. 1987. **Peopleware: Productive Projects and Teams.** Dorset Publishing Company, New York, N.Y.

Drucker, P.F., 1973. **Management: Tasks - Responsibilities - Practices.** Harper and Row, New York, N.Y.

Hersey, P. and K. Blanchard. 1982. **Management of Organic Behaviour: Utilizing Human Resources.** Prentice-Hall Inc. New Jersey.

Jones, C. 1981. **Programmer Productivity: Issues for the Eighties.** New York Institute of Electrical and Electronic Engineers, New York, N.Y.

Martin J. and McClure C. 1985. **Structured Techniques for Computing.** Prentice-Hall, New Jersey.

Yourdon, E. 1986. **Managing the Structured Techniques,** 3rd edition. Prentice-Hall, New Jersey.

GIS: PICTURE OR PUZZLE PIECE?

Jim McDougall

Manager
AT Product Development Automation Technology Division
H. A. Simons Ltd. 401 W. Georgia St.,
Vancouver
British Columbia V6B 5A1

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

GIS and its forerunners have traditionally operated as a stand-alone system to provide long-term forest management planning as well as short-term operating plans for operations. With the building today of large information databases through theintegration of financial and production reporting systems, is it still appropriate to treat GIS as a stand-alone or does it really belong as another piece of the business's information base?

INTRODUCTION

Good afternoon ladies and gentlemen, I am pleased to have been invited to talk to you this afternoon. In an environment where, with some justification, MIS people have been considered the enemy, I consider this an important opportunity to show that MIS does have a significant role to play in relation to GIS.

As the world shrinks and third world countries, whose resources have been largely untapped, start to develop these resources, the markets which our forest industry supplies grow in competitive intensity. Cheaper labour rates, faster growing forests and other less expensive operation costs give these countries a competitive edge in the market place. While we currently enjoy the advantage of higher quality products because of the inherent characteristics of our forests, the difference in selling price, if it continues to grow, will persuade our customers to find ways of adapting his processes to use the cheaper products.

The onus is on us, the forest industry, to be as effective a competitor as we possibly can GIS on its own, is in itself, a tool that aids competitive effectiveness. There is, however, a much more powerful tool created if GIS becomes a piece of a much larger system.

GIS - A HISTORICAL PERSPECTIVE

In order to look ahead, it is useful to stop and look behind. GIS in the forest industry, has gone through several phases in its evolution to reach the point it is at today. While the following phases and their time frames have varied from company to company and by region in Canada, they can be viewed as reasonable norms.

FIGURE 1

Figure 1 represents the general level of mapping up to the early 1960's. It contained nothing more than topographic and notable terrain information. The average forest company maintained relatively little information on their cutting licenses beyond these maps.

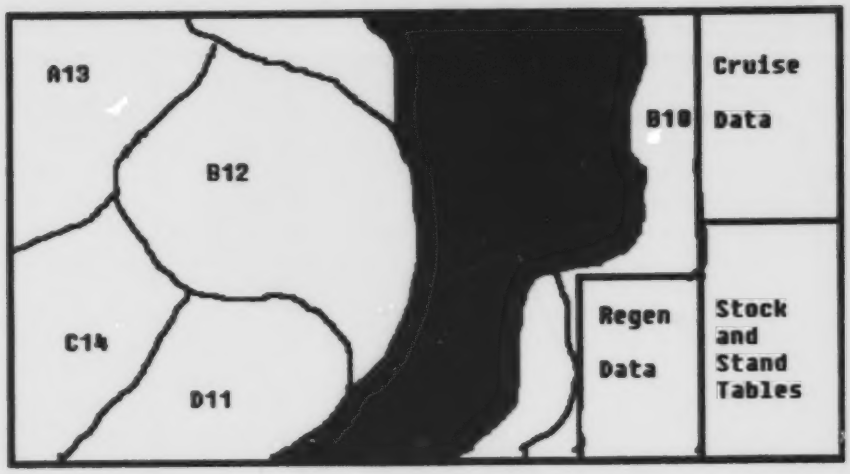
FIGURE 2

By the mid 1960's most companies had added, as illustrated by Figure 2, another type of data to their knowledge base. Stock and stand tables had been generated for the various species on their limits. Concurrent with this, companies and governments had started to cruise the forests to develop timber inventories to determine what the real available resource was and how much could be harvested in order to balance replenishment.

FIGURE 3

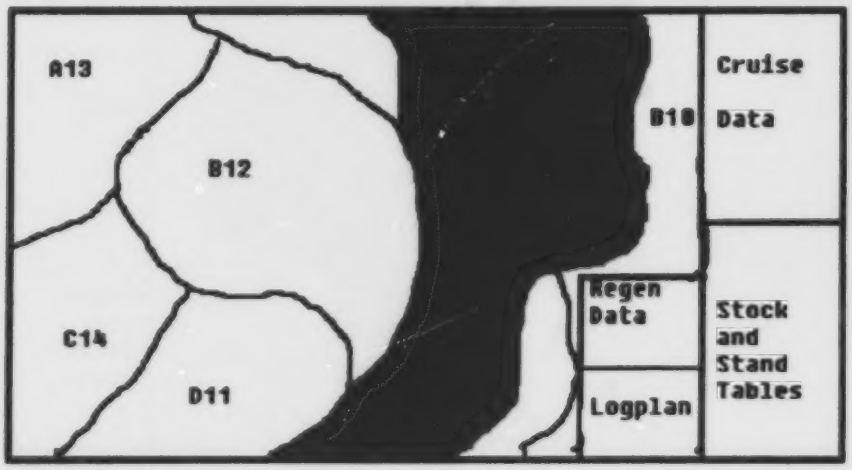
Late in the 1960's as interest, both public and governmental, began to focus on the forest industries' use of the "RENEWABLE RESOURCE", most forest companies added another piece to the forestry knowledge base. They began to collect regeneration data on the areas that had been harvested in the past. At this point in time, information existed as paper maps and manually kept books of tables.

FIGURE 4



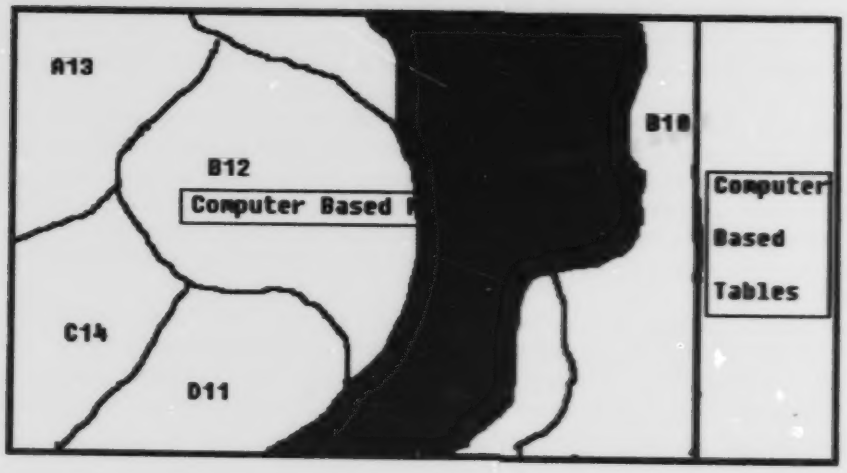
As Figure 4 illustrates, by the early 1970's, in response to the needs of forest management agreements dealing with allowable cuts and in response to operational needs for a more effective method of identifying areas to cut, and the planning for cutting, the concepts of logging chances were implemented. These chances, contained in a logging chance bank, broke the licence up into harvesting blocks. In this process, additional information, as well as the existing information in the manually kept books on timber inventory and stock and stand tables now had a common reference point. Chance bank maps identified not only topography and terrain, but also cover type, stands, swamping, rockiness and other factors which related to the degree of difficulty in working in the area. These factors began to provide significant assistance to the operations personnel responsible for production planning.

FIGURE 5



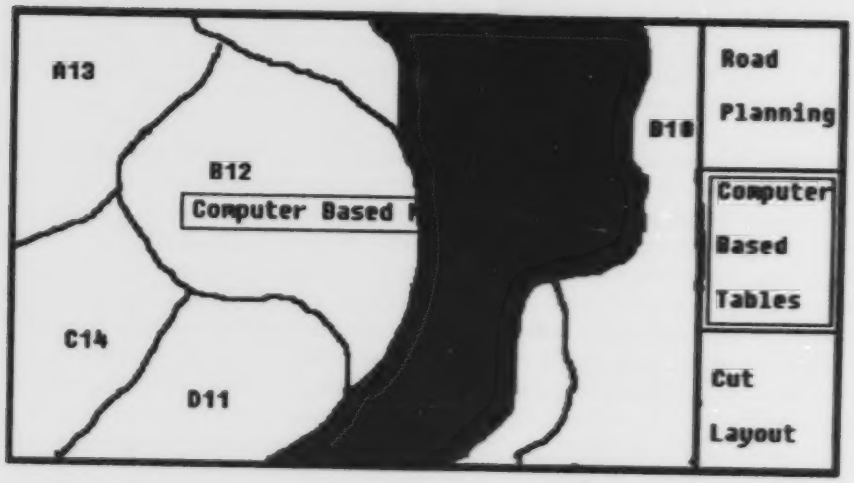
In the mid 1970's, another milestone was reached with the formulation of the LOGPLAN production model as shown on Figure 5. This computer simulation attempted to model the forest harvesting process to facilitate operational planning and scheduling. Although it had the potential for significant benefits, it was only utilized by very few companies. A number of factors worked against its widespread use. Most woodlands operations lacked some of the key data required by it. They had neither the computer personnel or hardware to be able to run it in-house. Finally, many operations lacked the management expertise to make use of what it could provide.

FIGURE 6



As Figure 6 indicates, by the mid 1980's computers had finally found a home in the forestry group. Many companies had transferred their mapping to computer-based environments. The tables, that were some of the first areas to be put on the computer in the late 1970's/early 1980's, had been integrated with the mapping.

FIGURE 7



Today, as shown by Figure 7 we have expanded out from simple mapping and applied various rules which allow the computer to generate road plans and cut layouts. The industry has come a long way but where do some of the more substantial paybacks for GIS come from? In the words of a song, "Is that all there is?" To look forward, it is necessary to look at what has been happening in the downstream operations, the pulp and saw mills.

GIS AND PROCESS CONTROL

One might note, as they viewed the previous diagrams, that each one has been enclosed by a picture frame. This is symbolic of the fact that GIS, in the course of its evolution, has existed as a stand alone system servicing the forestry department and providing assistance to operations. This is very analogous to the development over the same historical time frame, of process controls within the mills that woodlands deliver their product to.

During this timeframe, control of operations in the mill has evolved from manual control, through pneumatic and electrical control, programmable logic, and into the world of digital control systems employing advanced control strategies. Like the evolution of GIS, they have continually improved our ability to produce. But as we reach the 80/20 rule, we find that we can run our operations better, but have not accomplished a lot relative to managing them more effectively. This resulted in taking a closer look at what was needed and as a result, some new concepts were defined.

In the discrete industries the term "CIM - Computer Integrated Manufacturing" and in pulp and paper the term "MWS - Mill Wide Systems" were coined. They described an environment where the tying together of both process and MIS systems created an information base which would allow the development of management information systems which would give a comprehensive view of the total business. This would give management the information tools they needed to make better decisions.

In the world of woodland operations management, the same problem of getting answers to key questions exists. Like the mill, the answers to the questions requires information from both the traditional MIS-based systems as well as information from the GIS-based systems combined together.

TYPICAL PROBLEM

In order to illustrate this point, I would like to follow through a simplified but typical scenario where this would occur. Assume for the moment, that you are the woodlands manager in an operational group that includes woodlands, pulp mill, paper mill and converting operation. It is March and you are running well and successfully relative to both budget and forecast. You are just sitting down to a management meeting that has been called on relatively short notice. Around you at the table so far, are the managers of the other mill facilities in the group. You start getting a nervous feeling as the group manager walks in with the divisional Vice President and the Vice President of Marketing and Sales.

This nervous feeling develops into a definite sinking feeling as over the course of the next two hours, you hear how a new product that was developed has been a run-away success in its test market. Since the converting operation in this group is the most suitable facility in the group to produce this product, the total group operation is to be swung over to produce this product. Nausea envelopes you as the impact of this is translated back through paper making to pulp requirements and then back to fibre. The bottom line is, there is going to be a significant change in the softwood/hardwood ratio to be delivered to the mill. Since the operation has to submit a new budget for the balance of the year based on the changed operation within a month, when this is backed from converting through the paper and pulp mill, you now have four days to put together a new operating plan and cost it. As the meeting breaks up, the group manager and divisional V.P. indicate to you their confidence that you will be able to hold the line on the cost of delivered fibre near to the current budgeted cost in order to minimize the downstream financial impact on the rest of the operations. You leave the meeting and head for the first aid post for a needed plop-plop, fizz-fizz.

If we were to follow this woodlands manager back to his operations and watch what happened, in order for him to submit his revised plan, we would typically see the following process. The weight of fibre of hardwood and softwood would be converted back to cords or cubic metres and serve as the input to the Chance Bank component of the GIS system. Out from this would come a series of sets of logging chances that would satisfy the volumetric requirements. Forestry would then eliminate those sets that fall outside their government submitted plans. Next, forestry and operations would convene to review the remaining sets. The first round of elimination would kick out

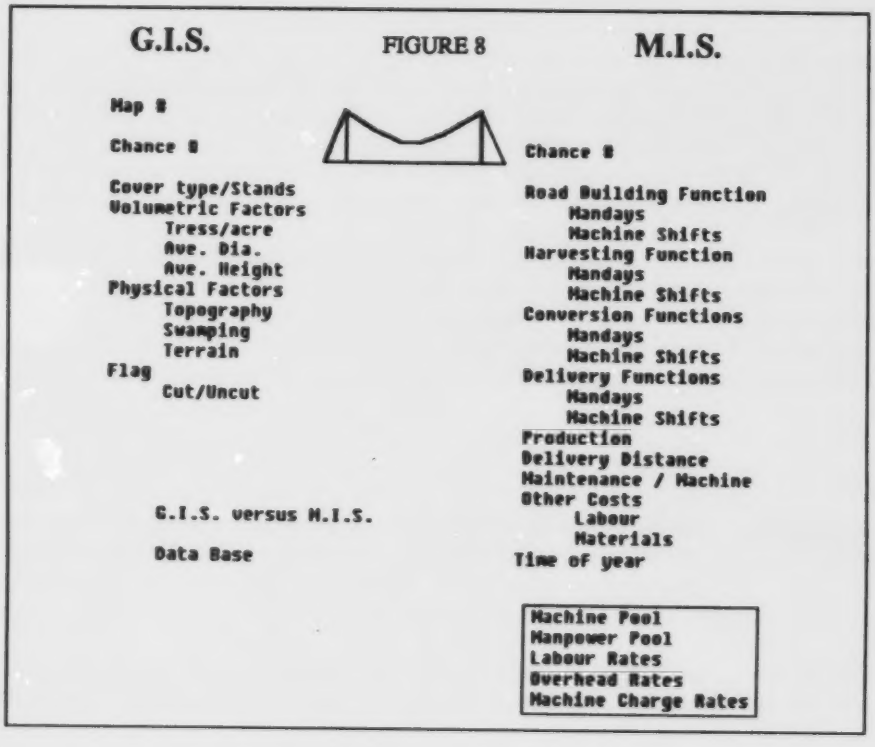
those sets that are not at all feasible due to access to the existing road system, or because of seasonality for cutting and hauling. At this point in time, they are now down to three or four sets of ten or more chances that meet basic acceptability criteria.

Now operations has to sit down and try to develop a harvesting plan for each of these sets, trying to balance cutting seasons, hauling restrictions, manpower, and machine resources, as well as determine the best harvesting method for each chance in each set. Given the time constraints and the amount of work involved in going through this process, it is likely that operations will find enough reasons to reduce the number of sets to no more than two. After two late nights, operations delivers to the costing group, a plan involving one set for final costing work-up with the hope that the delivered cost will be close enough. On the fourth day, the woodlands manager presents the new plan to the area manager and hopes that his boss doesn't ask too many questions. The delivered cost is significantly different from his prior budget and the only response available is that it is the result of a change of plan.

In summary, the process starts with a set of volume requirements that flows into a part of a GIS. The output from this flows through an educated guessing process and then finally through a part of the financial system. One would think that there must be a better way!

DATA RELATIONSHIPS GIS-MIS

Since we know what we have available from the GIS side, the key for finding a better way must lie over on the MIS side of the house. A good labour and production reporting system in this area would have been capturing a significant amount of information about our operation. This information would include labour hours and dollars, machine hours, production, maintenance and other costs relating to each area we have harvested. This would be broken down by the various functions such as road building, harvesting method, conversion method and delivery method. This information was needed in order to produce the typical management and financial reports. If we take this information base and try to align it with our GIS information base, we are likely to arrive at something that looks like Figure 8.



One can see that if we align the two information bases, a bridge relationship can be built between them because chance bank is a common reference to both environments. The question then becomes "What is the value of building this bridge and integrating GIS with MIS?" To find an answer to this question, let us mate the GIS system with the MIS system and develop a system on top of them which encompasses the new capability. With this enhanced GIS/MIS system we will revisit the problem the woodlands manager faced and follow the process as this system tackles the challenge.

The process starts in the same manner as the volumetric requirements are entered into the system. The system starts out as before, by first developing a series of sets of chances that met the volumetric requirements. Rather than simply kicking them out for human analysis, it would follow down a logical process. It would determine whether or not these areas were available to it by examining the forest management plan. Next it would examine road building and hit road building requirements against road building resources availability. Any solution that required significantly more road building capability than was allowed would be eliminated. In the process, the system would look back at other logging chances with similar terrain characteristics and then hit against the MIS historical data to determine productivity, to arrive at resource constraints as well as costs. In the same manner it would work its way through the various harvesting methods, and then conversion and delivery methods, eliminating sets that fail to pass resource availability requirements. In the end, a few hours later, a set of reports would be available to operations for review. Each of the alternative sets would be fully cost estimated and the reasons for a given set failing the system's criteria would be documented. As well as viable sets, the system has tried to optimize a production schedule since it can look at the actual experience for similar areas cut in different seasons.

At this point, operations can use their experience to factor in elements that have not been quantified in the MIS system. Potentially, the system could facilitate playing "what if" games, allowing operations to change resourcing requirements to see what the costs would look like for sets that failed resource requirements. The final product would be a group of production plans detailing costs and fibre deliveries to the mill. Pulp mill inventory requirements for production could now be logically evaluated. Overall delivered costs versus making up short-term inventory short-falls by outside purchases could be balanced. The net result is a plan which the woodlands manager could present to the area manager, backed up by sufficient information to justify costs and schedules, as well as alternative plans that might reduce his delivery costs but cause significant problems for the pulp mill.

In this example, the system was volumetric driven. Conceptually, the system could be driven in reverse by using manpower and machine availability to determine production output, generating chances, volumes and schedules as its output. In either case we are using GIS/MIS as a high powered planning tool. For those who have had some familiarity with the old LOGPLAN model, you will see many similarities with what LOGPLAN was trying to accomplish. The concept is basically the same but the execution is drastically different. The integration of GIS with MIS allows the building of a new type of model which overcomes the major obstacles LOGPLAN faced.

The GIS/MIS system can be used in other ways. With GIS's display capabilities tied to the MIS information base, many types of management information can be presented in a geographical context rather than the tabular form most managers are faced with. This type of picture format would allow managers to quickly key in on problem areas that require their attention without sifting through mounds of numerical information. The sooner management's attention is focused on these problems, the more likely they are to be solved quickly and profitability improved.

SUMMARY

In summary, it becomes clear that GIS is an important piece of the overall business information system. The synergy created when GIS and MIS are integrated gives rise to the development of a very powerful competitive weapon. Companies who integrate these puzzle pieces together and effectively use the results will have the competitive edge required to remain viable in the marketplace.

Integration is not a trivial task. It requires a high level of commitment to make it happen. GIS and MIS must be joined to work together, a task that compares in difficulty with getting process and MIS personnel working to-

gether. In many cases either MIS and/or GIS systems will need to be updated. In some instances GIS itself will have to be put in place. In some organizations, GIS has not happened because management has loudly asked "Where's the beef?" and the GIS proponents have been unable to generate sufficient financial justification. The one pound burger comes about as a result of the integration of GIS and MIS. These benefits alone justify having GIS. It will take time and money to develop the integrated environment but the competitive benefits are clear.

In the puzzle of the business information system, a piece of a puzzle has been sitting on a corner of the coffee table and the puzzle itself has a missing piece. GIS is that piece and it clearly belongs in the puzzle in order to complete it.

GIS, AN EVOLVING TECHNOLOGY: WHEN DO I JUMP IN ?

Alex Miller

President,
ESRI Canada Ltd.,
Don Mills, Ontario

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

GIS technology is evolving rapidly. New hardware and software are announced regularly. There are always some new improvements in the works. Since none of the existing systems are perfect the temptation is to wait for the next improvement. This paper will explore some of the areas in which changes have occurred and are anticipated. It identifies the issues that are relevant to acquiring a GIS. It also discusses strategies for keeping informed of the technology and avoiding hardware and software obsolescence.

HARVEST PLANNING ON A MICRO-BASED GIS: A DESCRIPTION OF THE MINISTRY OF FORESTS' "HARVEST MANAGEMENT SYSTEM"

Andrew Mitchell R.P.F.,

Planning Forester,
Integrated Resources Branch,
Ministry of Forests, Victoria, B.C.

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

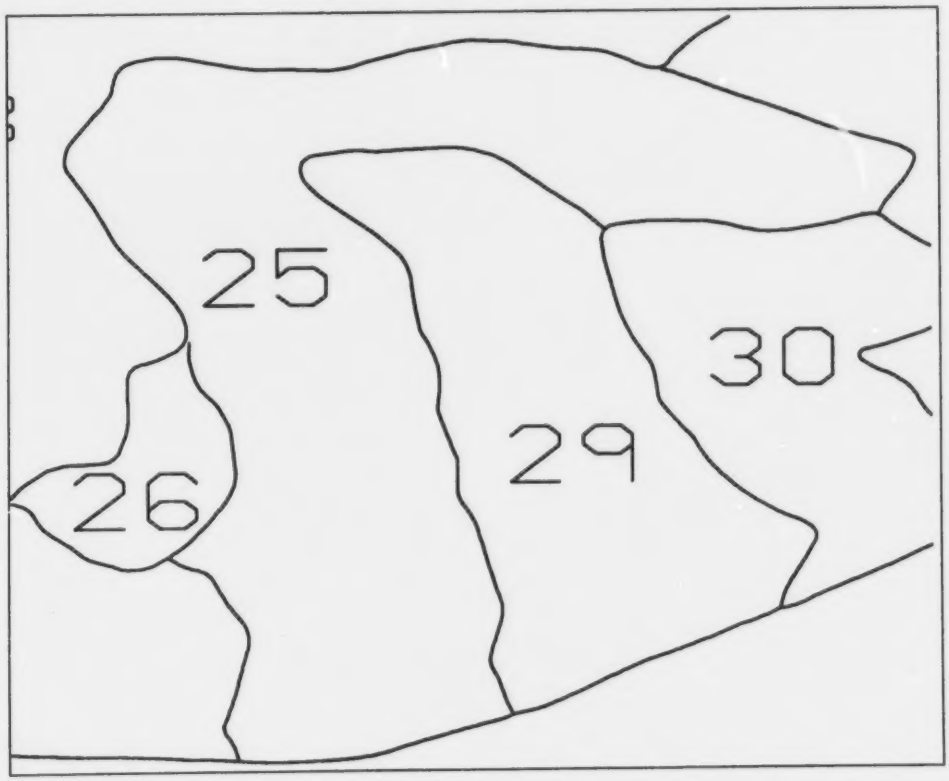
A user friendly program which operates in conjunction with a microcomputer GIS has been developed for operational use in harvest planning and management. It provides detailed information on costs and log values by harvest block. One, five, ten, twenty-five year harvest plans, total chance development plans, economic feasibility analysis, development and capital cost amortization, future timber growth projections, and harvest scheduling based on harvest chance are some of its applications. It is integrated with a digital terrain model for landscape management and it can interact with other forest information on GIS to facilitate integrated planning.

INTRODUCTION

The Ministry of Forests' "Harvest Management System" is a comprehensive tool for planning and managing harvest. It can be used for economic feasibility analyses on large areas of forest, for total chance harvest development planning on a drainage, or for operational harvest planning and management. The need for a special treatment during harvest to protect other forest resources can be indentified. A forester can use the tool and interact with other layers of forest information on the GIS.

GIS is a site-specific tool. It provides information on a defined space on the ground. A harvest tool in GIS deals with information on harvest of the site. Road costs, haul times and costs, the method of logging and expected productivity on the site are some of the main items. Other information on the date of logging, environmental concerns regarding fish habitat, landscape aesthetics, etc. is important but highly variable according to the situation. The program enables a list of these items to be created to suit local needs.

The following diagram is a section of a total chance harvest development plan. Data on harvesting a block can be entered while the GIS displays the harvest plan or map on the computer screen.



Block 25 is designed to be logged by short distance cable or highlead machine. Expected productivity on the site is entered. Costs of the men and machines employed are kept in a series of tables elsewhere in the program. Different tables can be created. One may contain cost estimates for a future time period to apply to the blocks to be logged at that time. Information pertinent to the harvest of block 25 shown previously is entered in the following table.

Map name	:	92F004
Block Name	:	25
Project	:	LUCKYCRK
Trip time	(min):	185
Load size	(m^3):	33
Truck cost	($/hr):	70 (6.54 $/$m^3$)
Rehab cost	($/ha):	0
Road cost	($):	270000
Fixed cost	($):	0

System	-- Production --			-- Shifts required --		
	fall	yard	load	fall	yard	load
SDC	110	270	480	251	102	58

Key Definitions

YEAR	: 2016
HARVEST SEQUENCE	: 2
DEV BY MAIN RD	: N

The key definitions at the end of the table enable user defined information to be entered for each block. Blocks can be included or excluded or sorted on the basis of this information to produce summary reports. A five year plan for blocks to be harvested between 2011 A.D. to 2015 A.D. can be produced by sorting for these dates.

An overlay process in GIS is employed to provide timber volumes by species for each harvest block. Ministry of Forests' digital inventory maps or generic inventory information from another source or cruise can be used. The "Harvest Management System" can report on expected future volumes based on growth equations if Ministry of Forests' inventory data is used. Estimated log grades and values can be entered in a table. These could come from a cruise of the area or they may be based on previous experience in the general area. Another table provides for selective logging of a block. Any percentage of each species can be removed. This facility can be used to reduce volumes to account for decay, waste or breakage.

Areas, volumes, species percentages, log grades and values and logging costs are calculated. The results for harvest Block 25 are shown in the following tables.

VOLUMES BY SPECIES

Species	% Logged	Volume Logged	-- Grade 1 --		-- Grade 2 --		-- Grade 3 --		-- Grade 4 --		-- Grade 5 --		Value
			name	%	name	%	name	%	name	%	name	%	
Ba	100	845	H	5	I	30	J	30	X,	30	Y	5	31,110
Cw	100	15 720	H	5	I	30	J	30	M	30	X	5	765,736
Yc	100	648	H	10	J	40	X	40	I	10		0	57,672
Hw	100	10 442	I	30	J	30	H	5	X	30	Y	5	381,310
TOTALS:		27 655											$1,235,829

Falling cost	:	$100,400	
Yarding cost	:	$168,300	
Loading cost	:	$51,794	
Logging fixed cost	:	0	
Rehab cost	:	0	
Haul cost	:	$180,864	
Fixed cost	:	0	
Road cost	:	$270,000	
Actual volume	:	27 655	m^3
Logged volume	:	27 655	m^3
Area	:	84.90	ha
Average log vol/ha	:	325	m^3/ha
Total cost	:	$771,358	
Total log value	:	$1,235,829	
Average cost	:	27.89	$/$m^3$
Average value	:	44.69	m^3

A total chance development plan for harvest of an area such as a drainage needs to account for many logging blocks. Capital costs of main roads, bridges, sorting yards and dumps need to be considered. There will be overhead and other cost items. The "Harvest Management System" has a series of capital and operating cost tables that can be applied to a harvest development. A sample table follows:

COST TABLE 1

PROJECT: LUCKY

	#	Description	Cost $
Capital Costs (lump sum)	1	ROAD TO ELLISWICK LK	227000
	2	ROAD AROUND TWOLAKES	208000
	3	BRANCH ROAD	100000
	4	3 BRIDGE CULVERTS	75000
	5	LUCKY CREEK BRIDGE	60000
	6	1KM ROAD DOWN LUCKY	150000
	7		0
	8		0
Operating Costs (per cubic m.)	1	OVERHEAD	8.85
	2	TOWING	1.05
	3	DUMP, BOOM, SORT, SCALE	4.22
	4	ROAD MAINTENANCE	1.24
	5	CREW TRANSPORTATION	3.15
	6	ACCOMMODATION	0.36
	7		0.00
	8		0.00

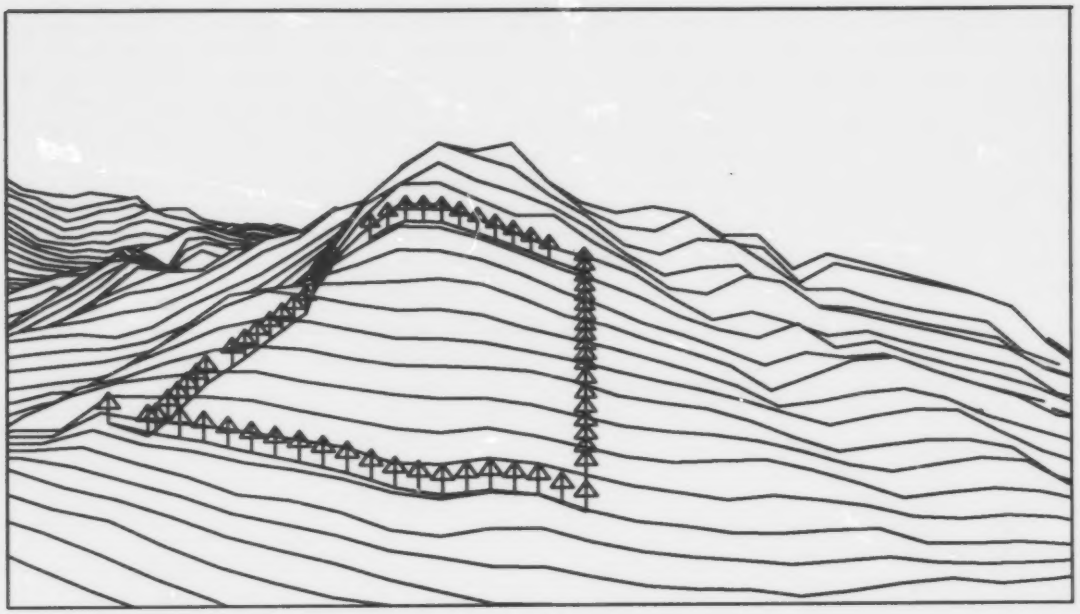
More than one table is available for each development to enable analysis of alternatives. Capital costs are amortized against the volume available for harvest in the development. A flexible reporting system permits the forester to examine and analyze the harvest development under a variety of circumstances. Harvest blocks can be included or excluded based on logging costs, harvest method or for millions of reasons based on user defined information. Harvest plans for different time periods in the future can be extracted. If a major branch road within the development is to be constructed in 1990 to service several harvest blocks along the road from 1990 to 1995, a summary report can be produced to provide costs and road amortization for this development within the larger area. The summary report for a harvest development plan lists all the blocks that have been selected, summarizes areas and volumes by harvest method. Species grades and values are listed and capital and operating costs are outlined. The summary concludes with an economic summary for the development as shown in the following table.

Total logging summary for forest unit

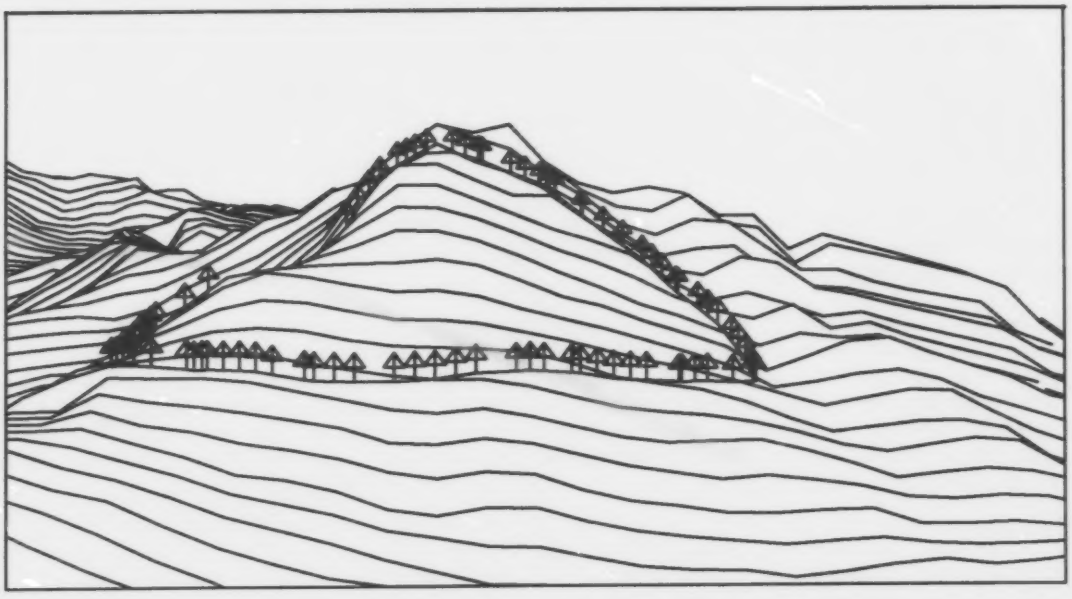
Total falling cost	:	$3,872,200	
Total yarding cost	:	$7,338,650	
Total loading cost	:	$2,100,511	
Total logging fixed cost	:	0	
Total rehab cost	:	$10,650	
Total haul cost	:	$5,749,129	
Total fixed cost	:	$149,000	
Total road cost	:	$7,085,004	
Total capital cost	:	$820,000	
Total operating cost	:	$17,777,446	
Total cost	:	$44,902,590	
Total value	:	$41,077,550	
Total volume	:	942,101	m^3
Total area	:	2,362	[illegible]
Average volume/ha	:	398.86	m^3/ha
Average cost	:	47.66	$/m^3$

A development can be analysed under a variety of different circumstances and the results compared. The software enables data from many harvest development plans to be combined for analysis and scheduling of timber harvest over large areas of forest.

Harvest has a major impact on the forest. It can affect other forest values and resources. The "Harvest Management System" facilitates planning and management of harvest and it provides necessary cost and value figures. The tool can be enhanced if it is used interactively with other information and facilities in GIS The "Harvest Management System" operates in conjunction with the Terrasoft GIS developed by Digital Resource Systems of Nanaimo. A digital terrain model attached to this GIS enables the landscape effects of proposed logging to be ameliorated. The following diagrams illustrate the modification of a proposed harvest block to reduce the visual impact.



Although the harvest block on the second diagram is larger than the first one, it is more compatible with the landscape.



In the previous example a harvest plan was modified because the visual impact was assessed on a digital terrain model. Development of forest management software for GIS to aid silviculture, watershed, recreation, forage, fish, wildlife and pest management would assist harvest planning. The forest management community should develop software for GIS that handles all aspects of the forest cycle.

GEOGRAPHIC INFORMATION SYSTEMS IN DEVELOPMENT PLANNING: A WORLD BANK PERSPECTIVE

Glenn Morgan

World Bank Environmental Department
Washington, D.C.

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

This paper examines the opportunities and constraints facing developing countries in the adoption of GIS technology in natural resource development sectors. The author reviews the current experiences of the World Bank, a leading international development agency, in the introduction and use of this technology for the promotion of more effective approaches to natural resource development planning and management. The paper covers the role of the Bank in natural resource development sectors; the constraints imposed by lack of accessibility to high quality land resource information; the Bank's current strategy for GIS implementation; and the prospects for widespread adoption of GIS in World Bank supported activities.

INTRODUCTION

The purpose of this paper is to describe the context in which Geographic Information Systems (GIS) and related technologies (remote sensing, resource survey/inventory etc.) are used by the World Bank. The paper examines the opportunities and constraints facing developing countries in the adoption of GIS technology in natural resource development sectors and reviews the current experiences of the World Bank, a leading international development agency, in the introduction and use of this technology for the promotion of more effective approaches to natural resource development planning and management. The paper covers the role of the Bank in resource development sectors; the constraints imposed by a lack of high quality land resource information; the Bank's current strategy for GIS implementation; and the prospects for widespread adoption of GIS in World Bank supported activities.

BACKGROUND

The World Bank is, arguably, the leading multi-lateral development Bank. As such, the Bank maintains an influential profile in the economies of the developing world. A short list of objectives of the Bank would certainly include accelerating growth in economic output, expanding employment opportunities, reducing malnutrition and disease, slowing population growth and improving public sector program management capacity. These goals are pursued through a vast number of interventions and programs. Indeed, through its project lending operations, country economic and sector policy work, the Bank makes significant contributions to public sector development priorities of its borrowing member nations.

For example, in Fiscal year 1988, the Bank approved 221 loans totalling 19.2 Billion Dollars (US) for its less developed member nations. Many of these Bank projects, particulary in agriculture, forestry, manufacturing and rural development schemes both directly affect, and are affected by, the assured availability of natural resources. Since its inception the Bank has lent over 202 Billion Dollars for all projects a large percentage of them integrally linked to the sustained productivity of the natural resource base of the nation. In the forestry sector alone, the Bank approved projects totalling 167.5 Million Dollars in FY88 and over 1.5 Billion Dollars since lending operations began. From the figures presented in Table 1 we can see that the Bank's operational program continues to have a substantial focus on agriculture and rural development projects which today account for nearly 25% of all operational lending in FY88.

The Bank also plays an important, though variable, role in policy formulation in its member countries with regard to long range strategies within resource utilizing sectors. New types of development programs are emerging which will have subtle but potentially far ranging impacts on national economies. As structural adjustment lending programs receive increasing attention in coming years and as developing economies change and adjust to new initiatives, unforeseen and unintended pressures will no doubt emerge on the natural resource foundation upon which economies are based. It is in this development environment that the Bank strives to evaluate all projects and programs to ensure that they incorporate longer-term sustainable use of natural resources as a fundamental element in development objectives.

WORLD BANK INVOLVEMENT IN NATURAL RESOURCE INFORMATION MANAGEMENT

Because of the long term implications of project and policy initiatives on a country's resources, the Bank is concerned that national, state, and local governments are adequately prepared to design, evaluate, implement, and supervise large scale development projects. But it is not unusual for long term resource allocation decisions to be made in a resource information "vacuum". Comments made by Simonett several years ago still ring true for many developing countries today:

> *"Decisions on capital investment and resource development are made in an atmosphere of greater or lesser uncertainty.. the uncertainty is almost always greater in the developing than the developed world because of the weaker information base. As a result many projects in the*

TABLE 1

TRENDS IN LENDING, IBRD AND IDA, FISCAL YEARS 1986-88
(millions in US dollars)

Sector	1986			1987			1988		
	IBRD	IDA	TOTAL	IBRD	IDA	TOTAL	IBRD	IDA	TOTAL
Agriculture and Rural Development	3,761.7	1,015.7	4,777.4	1,946.3	984.0	2,930.3	2,932.1	1,561.8	4,493.9
Development Finance Companies	1,324.7	124.5	1,449.2	2,204.9	93.0	2,297.9	1,490.0	222.5	1,712.5
Education	577.7	251.5	829.2	173.5	266.3	439.8	654.9	209.1	864.0
Energy									
Oil, Gas, and Coal	213.0	18.1	231.1	605.4	82.0	687.4	325.1	63.0	388.1
Power	2,423.2	363.7	2,786.9	2,857.0	159.9	3,016.9	1,908.0	98.9	2,006.9
Industry	757.2	63.9	821.1	411.4	7.0	418.4	2,062.7	161.9	2,224.6
Nonproject	900.0	421.0	1,321.0	1,790.0	647.1	2,437.1	1,020.0	667.0	1,687.0
Population, Health and Nutrition	166.6	252.9	419.5	33.3	20.8	54.1	109.0	195.9	304.9
Small-scale Enterprises	264.5	10.0	274.5	405.5	16.0	421.5	493.0	20.0	513.0
Technical Assistance	60.1	77.8	137.9	15.0	88.9	103.9	15.2	80.5	95.7
Telecommunications	24.5	25.9	50.4	654.5	27.8	682.3	36.0		36.0
Transportation	1,253.8	244.4	1,498.2	1,145.8	600.1	1,745.9	2,117.2	525.3	2,642.5
Urban Development	944.5	173.0	1,117.5	1,234.6	234.5	1,469.1	1,108.5	607.8	1,716.3
Water Supply and Sewerage	507.3	97.5	604.8	711.0	258.4	969.4	490.3	45.0	535.3
TOTAL	13,178.8	3,139.9	16,318.7	14,188.2	3,485.8	17,674.0	14,762.0	4,458.7	19,220.7

TRENDS IN LENDING, IBRD AND IDA, FISCAL YEARS 1986-88
(percentages)

	1986			1987			1988		
	IBRD	IDA	TOTAL	IBRD	IDA	TOTAL	IBRD	IDA	TOTAL
Agriculture and Rural Development	28.5	32.3	29.3	13.7	28.2	16.6	19.9	35.0	23.4
Development Finance Companies	10.1	4.0	8.9	15.5	2.7	13.0	10.1	5.0	8.9
Education	4.4	8.0	5.1	1.2	7.6	2.5	4.4	4.7	4.5
Energy									
Oil, Gas, and Coal	1.6	0.6	1.4	4.3	2.4	3.9	2.2	1.4	2.0
Power	18.4	11.6	17.1	20.1	4.6	17.1	12.9	2.2	10.4
Industry	5.7	2.0	5.0	2.9	0.2	2.4	14.0	3.6	11.6
Nonproject	6.8	13.4	8.1	12.6	18.6	13.8	6.9	15.0	8.8
Population, Health and Nutrition	1.3	8.1	2.6	0.2	0.6	0.3	0.7	4.4	1.6
Small-scale Enterprises	2.0	0.3	1.7	2.9	0.5	2.4	3.3	0.4	2.7
Technical Assistance	0.5	2.5	0.8	0.1	2.6	0.6	0.1	1.8	0.5
Telecommunications	0.2	0.8	0.3	4.6	0.8	3.9	0.2	0.0	0.2
Transportation	9.5	7.8	9.2	8.1	17.2	9.9	14.3	11.8	13.7
Urban Development	7.2	5.5	6.8	8.7	6.7	8.3	7.5	13.6	8.9
Water Supply and Sewerage	3.8	3.1	3.7	5.0	7.4	5.5	3.3	1.0	2.8
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: Details may not add to totals because of rounding.

developing world have unexpected and usually undesirable outcomes... economically, socially, and environmentally. Since the major bases for economic development in developing nations lie in their natural resources improved information on these resources will reduce some of the uncertainty in decision making.'' [1]

Information on the nature, extent and productive potential of natural resources in developing nations is typically incomplete or out-of-date. Consequently, many agencies in developing countries are unable to monitor land resource changes; evaluate natural system dynamics; predict impact of proposed actions; or evaluate development alternatives. The implications for technically sound and economically sustainable resource exploitation are staggering. As environmental and natural resource management issues move to the top of the international agenda the impact of decades of neglect regarding the maintenance of land resource information will be strongly felt.

There seems to be an unquestionable need for better management of the world's natural resources and ecologically sensitive areas and the Bank's recent initiatives in the area of environmental assessment reflect a growing international concern. Within the Bank there is an implicit awareness that better approaches to natural resource information acquisition, management and dissemination are both required and desirable. Following a major institutional reorganization in 1987, the Bank made its first major step forward in the area of international environmental management in many years. These initiatives have raised the Bank's profile in the international environmental community and coincidentally the expectations of those who look to the Bank for leadership in this field.

The purpose of Bank's re-orientation with respect to environmental issues is to demonstrate the importance and pervasiveness of environmental issued in development work. The broad objectives of the Bank's Environment Department are threefold: improve the ways environmental aspects of individual Bank projects are addressed; encourage increased investment in programs directly addressing major environmental issues; and establish an institutional foundation for integrating environmental and natural resource management into the highest levels of national economic planning.

The range of responsibilities of the Bank's central environmental department include institutional environmental policy formulation, scientific and technical research, economic analysis, country environmental assessment, environmental management task forces and the establishment of a modest unit for technical assistance in the field of GIS/LIS, resource survey and inventory.

GIS IN THE CONTEXT OF BANK PROGRAMS

To promote and strengthen its technical contribution in this field, the Bank has developed internal capabilities in the fields of GIS, digital image processing, resource survey techniques and digital database design. Within the Environment Department the unit is known as the Center for Earth Resource Assessment (CERA). CERA has two broad operational objectives:

i) improve the extent to which information about the nature and geographical extent of natural resources and environmentally sensitive areas is used in the identification, preparation, appraisal and supervision of Bank projects; and

ii) promote the widespread use of cost-effective methodologies and technical innovations for natural resource survey, inventory, baseline and database development programs of the Bank's borrowing members.

Within the Environment Department we believe that GIS and supporting technologies such as satellite remote sensing can and should provide valuable decision support functions at local, regional and national levels.

---

[1] *From paper by David Simonett, citation unavailable*

To address these goals CERA has developed a work program which focuses on three interrelated sets of activities:

i) development of internal GIS, Image Processing, CAD/CAM capabilites;

ii) incorporation of these technologies into the Banks lending program; and

iii) development of collaboration between the Bank and external scientific bodies, international agencies, bilateral donor programs, and the private sector.

INTERNAL GIS CAPABILITIES

The Bank's Environmental Operations and Strategy Division (ENVOS) has established a Geosystems facility which functions primarily as a demonstration or "proof of concept" center where Bank staff can, with the assistance of systems specialists, learn about the strengths and weaknesses of a number of different GIS hardware and software workstations. The objective of the Bank's internal capability is not to establish a fully developed GIS production facility nor to compete with private sector contractors. Rather our aim is to serve in an educational way, helping staff appreciate the contribution of GIS. Currently the Center for Earth Resource Analysis (CERA) maintains in-house demonstration and research facilities for automated GIS, Image Processing, and CAD/CAM.

One example of a GIS study the Bank has recently completed is a Soil Erosion modelling exercise for the Indonesian island of Java where polygon overlay techniques were used to generate erosion risk assessment maps for the entire island. The resulting analysis was used as direct input into an economic model which attempted to calculate approximate dollar cost of soil erosion to the local economy. CERA has also recently completed a household energy supply study in Pakistan where GIS modelling capabilities were used to identify the number and location of settlements which could be efficiently serviced through the introduction of solar energy. Yet another example is a simple land cover and land use database development activity for Western Bhutan to illustrate the utility of GIS for land use planning and management studies throughout the country. The CERA Geosystems laboratory conducts about 10 such demonstration activities per year. The Bank's CERA lab facility is not intended as site for the systematic development of large global databases on the state of the world's natural resources. Rather, we see our role as a node in a larger "network" of information centers world wide.

PROJECT LENDING EXPERIENCES

A second element of the ENVOS strategy to operationalize GIS is to encourage the incorporation of GIS as components of Bank funded projects. From our perspective, GIS is seen to provide four levels of information management and analysis. These functions can be summarized as description, diagnosis, prediction, and prescription. The simplest functions of GIS are related to technical record management functions. They tell us the physical extent and nature of the information stored in the database. The diagnostic functions of a GIS should tell us what is wrong. For example it may, as in the Java soil erosion model, help to explain why a situation has occurred. GIS can also help in predictive analysis to answer "what if" scenarios. These capabilities can help to examine the impacts of decisions made today on the quantity and quality of resources available in the future. The final function of GIS in operational lending is the prescriptive function. This function describes what should be done to help ameliorate or mitigate.

Incorporation of GIS into Bank projects is primarily a *capacity building* exercise typically focusing on the introduction of GIS into line agencies such as Department of Agriculture, Forestry, Soil Conservation, or Watershed Management. To date there have been no "free-standing" GIS or resource mapping projects financed by the Bank. Rather, our approach has typically been to include these capabilities as part of a larger, sector specific loan. Countries where the Bank has or will soon support GIS programs include Brazil, Indonesia, Papua New Guinea, China, India, and Pakistan, to name a few. While the number of projects with GIS components has been a very small proportion of Bank lending in resource sectors, the interest is growing and requests for assistance are increasing steadily. Several lessons have emerged from our practical experience in the developing world and these are summarized in the following sections.

COLLABORATIVE EXTERNAL PROGRAMS

To date, it has been the international development agencies which have been the principal moving force behind the introduction of GIS technology into the developing world. For this reason, ENVOS actively pursues co-operative natural resource and environmental database development programs with many international agencies and non-government organizations. We feel it is important that efforts be made to pursue joint, collaborative efforts with other agencies to ensure that the development community's message regarding natural resource information management systems is consistent and technically sound.

In particular the Bank has developed joint programs with UNEP, FAO, the International Geographical Union (IGU), and SIDA (Sweden). The Bank has also assisted in the development and execution of numerous joint projects with the United Nations Development Program (UNDP) in the field of national mapping and database development activities.

In addition, the Bank has also proposed a plan for establishing a network of national environmental information centers which would be built around GIS technology. These centers would act as clearinghouses for available information on a nation's natural resources by collecting and disseminating information which is dispersed throughout many agencies. They would also act as centers of excellence for resource survey design, database development planning, and professional education and training.

The Bank's efforts are representative of a wider recognition within the development assistance community that resource information management programs are an important development activity with implications across many sectors. Initiatives similar to the one evolving at the Bank are well established or are merging within such agencies as the United States Agency for International Development (USAID), CIDA (Canada), SIDA (Sweden), United Nations Environmental Program (UNEP), the Food and Agricultural Organization of the United Nations (FAO) and the Organization of American States (OAS) to name a few.

Still, the impact of the Bank's operational lending program on the promotion of GIS should not be overestimated. The Bank, for example, has no explicit policy on the development of natural resource information systems.

In terms of operational lending the actual amount loaned for GIS development is very small, much less than 1% of total Bank financial commitments.

The real impact of resource information however can be seen when one considers the problems created for project design, implementation, and supervision activities where information is unavailable. A 1986 internal Bank study indicated that the preparation and implementation of projects totalling nearly $800 Million (US) was delayed due to lack of adequate land records. This figure has surely risen since then and will continue to increase as Bank lending for environmentally oriented programs increases.

While the prospects for GIS adoption in developing nations are strong, the reality is that routine applications of the technology may be further off than one might expect. Within the development community several different constraints to successful project implementation typically merge. These include institutional, technical, and fiscal constraints. These issues apply equally to efforts designed to promote information system development and should be considered before any GIS project is undertaken.

INSTITUTIONAL ISSUES

Perhaps the most important constraints to successful project implementation are institutional in nature. Generically, institutional problems relate to considerations such as how program priorities are determined; how government is organized to manage and implement programs; how staffing needs will be met; and how organizations with similar mandates interact; how access to information is guaranteed; and so on.

Clearly, developing countries have no shortage of high priority problems. The management of natural resource information, unfortunately, does not frequently rank highly as a priority for many developing countries. At the

risk of making gross generalizations and oversimplifications, governments typically lack the commitment and the resources to maintain current environmental and natural resource information at even minimally acceptable standards. It has been estimated that on average African countries are spending less than 1/10 of one per cent of GNP on generating information related to the status of their natural resource base.

Perceptions are critical in the public sector and, in general, GIS has been regarded as a sophisticated, costly, and unjustifiable expenditure. Consequently most nations in the developing world have not significantly transformed or improved the institutional apparatus for dealing with terrestrial or aerial surveys, mapping and resource information management. Many would argue that the international community of bilateral development agencies and multi-lateral development Banks have a special obligation to assist in the development and maintenance of the information databases.

Other institutional limitations are related to shortages of trained staff, unpredictable data availability, and a lack of a strong planning tradition. GIS programs will often not meet expectations because we overestimate the impact of planning in the context of developing economies. In far too many situations the incremental value that improved information management makes is unperceived. All of these factors will limit the potential contribution of geographic information systems to development activities in the short-term. But pointing out these problems is only accentuating the obvious. All projects in developing countries face these types of constraints. They are not unique to the GIS and Resource Information management field.

Critics of GIS, remote sensing and resource information management in the Bank maintain that GIS and Remote sensing technological diffusion is largely supply driven as opposed to being demand driven. In developing countries, almost without exception, GIS are conceptualized and supported by outside donor programs. Those who make decisions about introducing GIS are often from cultures different from those whose lives are being affected and the success of "*technology transfer*" is frequently defined in the innovators terms while the value to the receiving beneficiaries remains questionable.

There are many in the Bank who would suggest that the technologies of GIS and more specifically satellite remote sensing are "cures looking for an illness". In far too many cases, they maintain, GIS implementation has been as a result of a technology push rather than serving an articulated or felt need on the part of the user. Like so many technologies developed for industrialized economies, systems introduced in this way are rarely self-sustaining and remain a bad technological "fit".

Our experiences with national remote sensing centers, for example, has indicated that many line agencies consider the contribution of such centers to be marginal. Large centers typically have not interacted with the day-to-day managers of natural resources and are seen as ivory tower, hi-tech gurus. It is far too typical to encounter systems which have been justified on the basis of ill defined user needs. Usually, users of the GIS are identified simply as development planners or policy decision makers. Data requirements for national resource management programs are likewise generically defined. Seldom have systems met their stated objectives because the data or processing capabilities often do not meet specific needs of specific users. Consequently the many capabilities remain underutilized and the products of the information system make no lasting contribution.

Many institutional issues raise the question of whether or not GIS can be considered appropriate technology for developing countries. While an often used phrase in the development literature, appropriate technology means different things to different people. An important issue from the Bank's perspective is whether the transfer of any technology increases or reduces the levels of technological dependency. If the implementation of GIS greatly relies on expatriate expertise for hardware, software, equipment maintenance, and training to remain viable then it could be considered inappropriate. Of course, there are trade-offs to be considered. Obviously we invite difficulties when indigenous technologies are promoted which are obsolete. This is frequently the case in data processing and computer applications.

Another institutional issue related to technological innovation is the degree to which the new technology will cause institutional distortions. New technical approaches almost always affect many workers and can lead to job displacement and modified responsibilities at al levels in an organization. We have seen many examples where

the use of GIS and Remote Sensing technologies have led to intense interdepartmental rivalries and personal jealousies. The introduction of automated data processing facilities - a source of pride and a sign of accomplishment in many agencies - has, in some cases, resulted in the "modernized" departments becoming quite isolated from their counterparts with a consequent reduction in effectiveness.

FISCAL ISSUES

Another set of implementation problems arise due to government fiscal constraints. Few Governments in the developing world systematically and consistently fund mapping and surveying programs. This is especially true with respect to land use and land capability mapping programs. Part of the explanation lies in the poor understanding of how mapping and database programs can make a difference to development planning.

One of the major challenges facing the expanded use of GIS technologies beyond the demonstration project phase is the problem of identifying clear-cut financial benefits from GIS use. The GIS community currently lacks unambiguous, empirically based accounting data on both cost reductions or the value of improved decisions. This is currently a bottleneck which has led to reluctance among development practitioners to push hard for its implementation.

From the Bank's perspective we see relatively little consensus in the GIS community as to how costs are to be derived. There is a poor definition of what the GIS "product" actually is which has led to a dearth of meaningful cost comparators. We perceive an even larger gap with respect to benefits assessment. This is because natural resource information is an intangible asset. By this it is meant that resource information has different value to different users; that the value of data changes over time depending on the urgency of user needs; and land resource information has an unpredictable life expectancy because land use changes can be swift and unanticipated.

Demonstrating the financial benefit of GIS is not as straight forward as it may appear on the surface. In general, we could state that the value of GIS is the value of the change in decision behaviour which it leads to, less the cost of acquiring and storing the information. In other words, the value of the information is in effecting changed behaviour. Typically this connection is not strongly made or perceived. Most GIS demonstration projects simply illustrate how the GIS might be used in a given management or planning scenario but few examples actually show how a different decision was made through the use of the technology. For these reasons, many governments have been reluctant to invest heavily in information system development programs.

TECHNICAL ISSUES

Finally, the Bank perceives that many institutions face substantial limitations with respect to the level of technology that can be absorbed in the GIS field. Despite a growing experience base in the developing world with computers and automated data processing the vast majority of developing countries have no formal training programs at technical schools or universities in the GIS field. Though this situation will be somewhat ameliorated by the ease of use of many GIS packages available today we still anticipate a substantial shortages of trained staff.

Other important technical issues relate to the need for standardization both in terms of procedures used by national, State and Local government but also in terms of the products supplied and used. This will become an increasingly difficult problem as the PC revolution leads to greater decentralization in database development. Service and maintenance contracts, reliability in power supply, provision of proper physical facilities, patents, copyrights and licensing regulations are important technical issues when working in developing countries. Each affects the productivity of the information system in its own ways.

CONCLUDING REMARKS

Despite the issues which we have addressed above the GIS community should not be discouraged by the factors working against successful implementation of GIS programs. Financial, institutional, technical and logistical problems are common in the developing world, and they are not unique to GIS implementation projects. And

after all, working to change these environmental constraints is what development work is all about. This GIS community should be prepared to play its role. Our goal as advocates of improved information availability and management should not be to remove all uncertainty in development planning but rather to accommodate it more effectively. The question should be "How can GIS programs be designed to achieve its goals more efficiently and with less risk to the supporting government."

The present position of ENVOS is that GIS, while a potentially valuable tool, should be introduced incrementally in a fashion which explicitly recognizes the institutional, fiscal, and technical constraints and tackles them head-on. Clearly, GIS is finding a place in the information management needs of developing countries. This has been due in a large part to the dramatic reduction in start-up costs for GIS workstations. (Incidentally, we generally support the view that PC based work stations are the preferred data processing environment to achieve the goal of incremental change. We are convinced that desk-top workstations should be widely promoted because, in addition to their ease of use and growing availability, they permit selective decentralization to regions or agencies which are capable of absorbing the technology now.)

In order to effectively disseminate GIS technologies in the developing world the GIS industry must continually strive to highlight its operational relevance. We must be seen as more than a "cure looking for an illness". We must be seen to understand the problems of the developing world and be precise about the role of spatial information in addressing those pressing needs. Within the development community there is still considerable skepticism regarding the role of resource information surveys, baseline environmental studies, and especially digital databases.

The connection between better natural resource information management and improved decisions is not clearly perceived in the developing world. Relatively few examples exist of how the use of GIS has actually led to different decisions or made significant impact on the policies of governments at any level. This means that as a discipline we need to be more explicit about where GIS has been used and how it has made a difference.

DATA INTEGRITY - MANAGING DATA FOR THE FUTURE

Reeler, E.C., M.Sc.E., P.Eng

Applications Engineer,
Universal Systems Limited,
Fredericton, New Brunswick

Masry, S.E., Ph.D., P.Eng

President,
Universal Systems Limited,
Fredericton, New Brunswick

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Users of geographic information systems are becoming more concerned with data integrity, particularly now that they are moving towards integrating different systems in distributed networks. This paper highlights many of the integrity concerns which users now face at this point in the evolution of geographic information systems.

INTRODUCTION

According to the Webster dictionary, definitions of the work "integrity" include:

1. soundness
2. incorruptibility
3. the state of being undivided
4. a firm adherence to a code

These apply particularly well to the concept of data integrity in a geographic information system.

Up until the present, the users of geographic information systems have successfully been able to merge spatial data from many sources and to edit and maintain the resultant databases in order to allow the user to access and process spatial information ina multi-user environment.

Present needs are now requiring users to extend their current spatial database capabilities in order to efficiently share data with other organizations. This has involved the integration of many different databases using different hardware and software and containing data formatted in many different ways. The future needs of geographic information systems users will be to maintain and extend these interconnected databases in an environment of rapidly evolving hardware and software.

These situations have posed many problems in terms of data integrity. This paper highlights many of the concerns which users now face at this point in the evolution of geographic information systems.

1. DATA INTEGRITY IN COMPILATION

"Data integrity" refers to the soundness of spatial and attribute data in a geographic information system. A primary consideration should be whether data integrity has been established in a database in the first place, namely at the data compilation stage. This is not only an issue involving the hardware, software and data structure, but also one which involves the management of the quality control process. Data which is "clean", in the sense that it conforms to data structuring rules, may not necessarily be useful or even correct.

Modern technology has enabled the merging of data sets of different spatial accuracies from maps of different scales containing data collected over different periods of time. Data collection is expensive and users often have to use data sets which were originally collected for some other purpose. This situation can lead to the danger of data conflicts and inconsistencies between data sets of differing age and accuracy.

Accuracy requirements are entirely application dependent, for example, property applications may require more accurate data than resource applications. Also revision cycles depend on the type of data being collected, for example, natural features such as rivers and relief are more stable over time than man-made features such as roads or buildings.

Nevertheless, the user must be aware of the spatial accuracy of different data sets in the system, when they were collected and the purpose for which they were originally collected. Both the accuracy and the age of data depend on data collection, however integrity can still be established in the system if each item of spatial data has an associated age and accuracy which are readily accessible by the user and by the system software. These properties can then be used to colour code different data sets in the same area of interest or to weight calculations performed by the system software.

Other ways of ascertaining data integrity within a system are by using software to perform internal data consistency check within a database as well as consistency checks between corresponding data records in separate databases to detect whether there are data conflicts or redundant records.

There are other integrity issues which are more of a data structure and systems software policy concern, for example, the resolution at which spatial data can be stored in the system, whether calculations are performed with single or double precision and whether figures are rounded off or truncated. Although these issues do not substantially affect data accuracy, they may affect the matching of data at map edges and the connectivity of lines on a map and lead to troublesome inconsistencies between adjacent data in the database.

2. DATA INTEGRITY IN ACCESS AND UPDATE

"Data integrity" also refers to the incorruptibility of spatial data in a geographic information system. Data could be corrupted by situations such as unauthorized editing, or system breakdown during a transaction. There are also dangers of corruption in a multi-user environment when two users are performing updates on the same data or during two simultaneous transactions when one user is updating data used by the other user.

At present these problems can be overcome through data security software and procedures. There are rollback facilities to recover from a system breakdown and data locking procedures to protect data during simultaneous transactions. This is known as concurrency control. There are also transaction verification procedures which allow the user to abort a transaction if desired.

Problems in ensuring incorruptibility can be further compounded when there are distributed databases and networks of interconnected systems. Usually each department in an organization is placed in charge of its own specific data and data security is implemented to prevent any unauthorized updates. This is done by permitting other users to access the data but not to update it. This type of data security needs to be implemented across systems in a network. Some users achieve this by sending a set of update instructions to other sites in a distributed database while others prefer a centralized database concept.

However, when complex configurations of databases are involved, it is clear that in order to preserve the incorruptibility of the data and still have flexibility in a network of systems, it is also a necessity to have systematic update procedures and sound data organization across systems in the network, as well as efficient system management.

3. DATA INTEGRITY BETWEEN SYSTEMS

"Data integrity" also refers to the wholeness of spatial data in a geographic information system and more particularly in a network of different systems.

Many users need to closely interrelate the data contained in several different databases, but require the network to respond and function as if it was a single database. A typical example of this is a geographic information system whose graphic elements possess associated textual attributes contained in several textual databases. For the network to function as a single system reliable links need to be established between elements in the geographic information system and records in the textual database. There should also be checks to detect redundant records and missing records as well as procedures for concurrency control and recovery after a breakdown of any one of the components of the network.

Threats to data integrity also include incompatibilities caused by new hardware and software which are both rapidly evolving in the geographic information systems industry. More robust data structures, software which is upward compatible and software which is portable between databases on different hardware have definite advantages in such a rapidly evolving industry.

There are also integrity concerns about the loss of data when translating between incompatible data formats on different systems. Here the solution may be to encourage inter departmental cooperation in adhering to agreed upon compatibilities, standard data formats and translation procedures.

4. CONCLUSION

In past years, geographic information systems have been used for merging and maintaining spatial information for data processing and access in a multiuser environment. At present there is increasing emphasis on data sharing and the networking of existing systems. Consequently data integrity control, which was manageable in a single system is now becoming more of a concern to users.

There are many solutions to problems of data integrity in terms of data structure, software and integrity mechanisms. However all of them depend very strongly on the initial existence of data integrity in the network. It is clear that to achieve this, the organizations and departments involved in sharing this data have to first agree on compatible data accuracies, data structures, formats and standards. In other works, data integrity must first be established and can more easily be maintained by the "firm adherence to a code" of standards compatible with and agreeable to all concerned.

CREATION OF FOREST INVENTORY MAPS USING AIRBORNE DIGITAL IMAGERY AND GIS

N. Reid

MONITEQ Ltd.,
Concord, Ontario

J. Fisher

Marshall Macklin Monaghan Ltd.,
Don Mills, Ontario

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT OF POSTER

The management of forest resources requires timely and accurate information in a format providing ease of manipulation for those involved in the decision making process. One approach to managing these resources is the Ontario Forest Resources Inventory which provides a database of forest resources, updated on a twenty year cycle, available to forest managers for planning and decision making.

In the current work, recent technological advances in the fields of Airborne Digital Imaging and Airborne Image Registration were used to create a Forest Resources Inventory database and input it to a Geographic Information System (GIS). An area equivalent to two Ontario Base Maps (OBMs) was surveyed using 5 metre resolution airborne imagery. The airborne imagery was geometrically corrected, registered to UTM co-ordinates and classified for tree species, maturity and stocking. An automated process was developed to convert the classified imagery to a polygon vector coverage. Examples of unclassified imagery, classified imagery, and the polygon coverage of the test area are presented.

TRAVELING DOWN THE YELLOW BRICK ROAD TOWARDS INTEGRATED RESOURCE INFORMATION SYSTEMS

Don Reimer, Ph.D.

President
D.R. Systems Inc.
Nanaimo, B.C. V9R 5B3

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

GIS consists of three components or functions; data loading or conversion, maintenance of graphics and attribute databases and applications or analytical capabilities. The real benefits of GIS come from industry, and even company, specific applications. Unfortunately the economic reality of the GIS software industry dictates that the applications provided by the GIS vendors be generic to a number of industries. As a result, the forest industry and individual users must develop applications suitable to their own requirements. This paper discusses the integration of GIS with simulation models used for analyzing fibre supply strategies over the near and long term.

INTRODUCTION

When Alice in the story "Alice in Wonderland" asked for directions, she was asked where she was going. When she replied she really didn't know, the answer was given that it didn't really make any difference which road she took as they obviously all went somewhere.

It has been my experience that this general lack of knowing where you wish to go has been one of the basic problems in the implementation of GIS-based information systems. While a GIS is a key component, a GIS package is only one item that is needed in a resource information system. You will also need software, and a methodology, for controlling and updating your basic resource inventory information. Similar needs apply to the growth projection system used to forecast the future inventory and to the planning systems used for making short-term, operational and longer-term, strategic plans.

All of these components are essential parts of any resource information system, and, in the case of the newer GIS-based approaches to information management, must be fully interfaced and integrated with each other before full benefits of an expensive GIS system will be realized. By carefully defining the objectives of the new information system (i.e. which management teams is it going to support and what applications will they be using it for), and by using an integrated approach to the implementation of the various components of such an information system, it is possible to purchase, install and successfully implement a GIS-based resource information system within a realistic budget and time frame. The key phrases are *defining objectives* and *integration of components*. Failure to do a good job in either of these areas makes it difficult to make much progress down the yellow brick road.

Given the above context, I will discuss my experience in integrating and implementing forest growth models into today's GIS-based information systems.

FOREST GROWTH MODELS

One critical component of any forest-resource based information system is the forest growth projection sub-system. As we move towards a second-growth forest economy, growth and yield models become critical tools in the planning and scheduling of silvicultural treatments and harvests.

In order for a given growth model to be useful in this work, it must be fully compatible to and integrated with not only the forest inventory database, but also with the stand history records and silvicultural treatment codes and databases. In addition, the output data generated by the growth model(s) must be compatible with the requirements of the particular forest planning models being used. At the moment, very few, if any, growth models have been developed with any consideration at all for the types and reliability of data which is normally collected in forest inventories. Considerations relative to the utility of the output from growth models for use in planning models and scenario generators has had even less attention.

This current state of affairs is slowly changing.

However, given the information requirements of forecasting tree and stand growth, and the increasingly sophisticated requirements of land managers, there will have to be some changes and additions to the information collected in forest inventories before direct and full integration will be achieved at the general level.

I recently attended a growth and yield workshop where one topic of discussion was the expected characteristics of future growth and yield models and the type of information which will be necessary to drive them. These growth models are being and will be used to help develop increasingly sophisticated forest management plans. Information requirements for forest management planning now include a wide range of environmental and aesthetic impact analyses, in addition to the more normal descriptions of tree sizes and volumes available at various times in the future.

One way to look at these future forest inventory and growth model information requirements is to look at these information requirements as part of a larger corporate information need. For example, if corporate objectives

include mill modernization or expansions, then it will be necessary to be able to forecast future piece sizes, and possibly expected ring widths, in addition to the normal information on volumes and dbh class ranges. Past and future silviculture practices will have to be tested in order to develop a proper forest management scenario which in turn will be tested against corporate objectives.

If pest management is a serious consideration, then some means of incorporating information which will allow forecasting of probabilities of pest infestations and intensities will be needed and will have to be included in the forest inventory database. The USFS is currently linking one of their growth models to a range of post processor models to predict big game cover and habitat, disease and pest impacts, water yields, recreational and aesthetic impacts, etc. These requirements all add complexities to the forest inventory databases as well as to the output requirements from the growth models.

Growth models which can begin to supply the basic information for these requirements will most likely be single-tree, distance independent models. Such models can handle mixed species, multi-age stand projections, can handle changes in stem form due to silvicultural practices, can handle changes in merchantability limits, and can provide future forecasts of forest stands by species, dbh class and log quality class. These models all require some estimator of inter-tree competition, usually based upon some simple assumptions about crown form and length. While these models are developed using permanent plot data, some of which must be stem-mapped, the only additional inventory information required should be information on length of live crown for each species present.

Information required for wildlife management, recreation and aesthetics, and water are currently based upon normal stand characteristics such as stocking, species, volume per hectare, habitat or ecozone characteristics, etc.; information items which most current inventories contain. Information necessary for pest management includes the normal information on stand and site characteristics plus some information on the occurrence of the pest or disease. General forest inventories of the past have not adequately addressed these needs and some additional information specific to each category of pest or disease will have to be collected and put into the inventory.

CONCLUSION

While I do not expect every organization will have all of the above information requirements, it goes without saying that the information requirements of future managers will be significantly greater than today's. One of the major capabilities provided by a GIS-based information system is the ability to generate forest land management scenarios which include the spatial and geographic relationships of the resource base for all resources concurrently. However, before such potentials can be realized, all the pieces of the complete management puzzle must be in place. Recognition of this requirement for integration is the key to realizing the full potential of your GIS system.

GIS-BASED DECISION SUPPORT SYSTEMS: A FOREST INDUSTRY PERSPECTIVE

Thomas W. Reisinger

Assistant Professor
School of Forestry & Wildlife Resources
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

The real value of GIS to forest industry lies in providing accurate, up-to-date information for making a variety of forest management decisions as well as generating current maps of landholdings for implementing these decisions. Relatively few companies, however, are using GIS as a tool for making operational and long-range planning decisions. This paper presents the results of a survey of GIS use by U.S. forest industry and describes a prototype Harvest Planning Decision Support System (HPDSS). HPDSS is one example of how a large-scale industrial GIS can be integrated with several operations research/decision models to create a DSS for planning timber harvests.

INTRODUCTION

Successful applications of geographic information system (GIS) technology are, in essence, decision support systems (DSS). This important difference is underscored by Cowen (1988), who states, "GIS can best defined as a decision support system involving the integration of spatially referenced data in a problem solving environment." Others suggest that GIS must evolve from an inventory tool to an analysis tool, and then ultimately to a management tool (Crain and MacDonald 1983). The realization that GIS is much more than "automated cartography" has caused many diverse groups to take notice, particularly in the field of natural resource management.

For many forest-based industries, GIS is a vital tool for handling the large volume of detailed inventory data and other stand-related information needed for more intensive forest management. In many cases, the justification for investment in and the initial use of GIS was based solely on map production. Shortly after the land base is digitized and the database constructed, development of more sophisticated GIS applications begins. The development process will continue to grow as GIS becomes an integral part of the firm's decision support process. Sieg and McCollum (1988) argue that integration of GIS with other decision support software makes justification of these systems easier and improves their overall usefulness.

Unfortunately, complete integration of GIS and DSS is an ongoing process that can and usually does take many years to complete. For Weyerhaeuser, integration over the past 15-20 years has become so complete that GIS and Forest Inventory are "inextricably linked . . . for the simple reason that it provides the most efficient and effective means of collecting, storing and distributing the timberlands management information demanded by the total organization" (Wakely 1987).

This paper presents the preliminary results of a recent survey of GIS use by forest industry and describes a cooperative research study with a major forest products firm to develop a prototype decision support system for planning timber harvesting operations.

FOREST INDUSTRY SURVEY OF GIS USE

A survey of major U.S. forest industries was conducted to determine how GIS is being used in their organization. The survey focused on large forest-based companies owning 100,000 acres or more that were known to have existing or recently acquired GIS systems. In a survey assessing future needs for remote sensing data, the American Forest Council (AFC) identified 81 different companies owning 100,000 or more acres; collectively, these companies own approximately 69 million acres of industrial forest land in the United States (American Forest Council 1988). When asked if they use GIS, 56 percent of the 36 companies responding to the AFC survey answered positively; collectively, these companies own 30 million acres.

SURVEY OBJECTIVES

A total of 18 different companies known to have a GIS system were contacted and interviewed by telephone during the course of this survey. (No attempt was made to contact all 81 companies identified in the AFC survey). Although the main purpose of the survey was to determine the kinds of GIS applications used by these companies, general background information about their GIS system was also obtained. This included:

1. Experience with GIS and date the system was first acquired;
2. Personnel (full-time) involved with GIS/Inventory system;
3. Hardware specifications;
4. Software specifications; and
5. Current use of the GIS system.

The combined forest land base for the 18 companies surveyed amounts to 37.9 million acres, or approximately 55 percent of the total industrial ownership estimated in the previously mentioned AFC survey. Several companies, however, do not have all their land base digitized. Roughly 21.3 million acres, or 56 percent, of their ownership is currently included in a GIS database. Recent mergers/land acquisitions, new installations of GIS systems, conversion to new software, and hardware upgrades are the major reasons why not all company lands are included in the GIS.

SURVEY RESULTS

The survey results, summarized in Table 1, indicate a wide range of GIS involvement. The following discussion should be considered preliminary because the results were obtained from only 18 companies with known GIS technology; contacts with other companies are planned. Although grouping was difficult and less than perfect, four separate classifications became apparent when the 18 companies were compared in terms of how completely GIS is integrated with other decision support software. As shown in Table 1, the four classifications are fully integrated, partially integrated, almost no integration, and none.

Fully Integrated. Five of the companies surveyed indicated that their GIS system was fully integrated into the management information/decision support environment of the company's operations. Typically, the companies in this category had more years of GIS experience (9.6 years); more personnel working with the GIS system (13 full-time individuals); one or more minicomputers (DEC VAX, Data General or Prime) and several microcomputers with graphics capabilities; and more sophisticated GIS software (Arc/Info, Intergraph, or software developed in-house).

Table 1 Integration of GIS/DSS for 18 forest-based industries

	Degree of Integration			
	Full	Partial	Almost None	None
Number of Companies	5	5	3	5
GIS Experience				
Average (yrs.)	9.6	7	5.3	1.2
Range (yrs.)	(4 - 15)	(4 - 9)	(4 - 6)	(0.5 - 2)
GIS Personnel				
Average	13	5.6	4	2.4
Range	(2 - 30)	(2 - 8)	(3 - 6)	(2 - 3)
GIS Hardware	Mini & Micro	Mini & Micro	Mini & Micro	Micro
GIS Software*	Arc/Info Intergraph In-House	Intergraph Comarc+A/I GeoBased	GeoBased Comarc Inter-Cart	Arc/Info GeoBased

**Mention of trade names is for information only and does not imply endorsement by Virginia Polytechnic Institute and State University.*

Well-developed applications, sophisticated analyses, and full integration into the management information/decision support process really distinguished these five companies from the others surveyed. These companies also appeared to be continually developing new macros/applications for a variety of in-house clients ranging from field foresters to upper management. In addition to the routine GIS functions of map production and inventory maintenance/update, many of these companies have developed specific macros in the following areas:

* Harvest Planning/Scheduling/Budgeting
* Forest Management Planning/Scheduling
* Long-Range Inventory Growth and Yield Projections
* Transportation Planning/Road Maintenance and Design
* Wildlife Habitat/Environmental Risk Assessment
* Strategic Planning for Land Acquisitions, New Mill Locations, and International Supply/Demand Analyses
* Corporate Accounting/Tax Record Maintenance
* Logging/Forest Management History on Fee Lands

Partially Integrated. Five other companies indicated that their GIS system was partially integrated with their company's decision-making software. This group was more difficult to distinguish than the previous fully integrated group because many were preoccupied with digitizing the balance of company ownership, converting to a new software system, redesigning their tabular databases, or upgrading their GIS hardware. As Table 1 indicates, these companies typically has slightly less experience with GIS (7 years); fewer full-time personnel (5.6); similar hardware configurations using minicomputers (DEC VAX or Data General) and/or microcomputers (Compaq 386) for primary processing; and a slightly different mix of GIS software (Intergraph, Comarc & Arc/Info, and GeoBased) than the companies classified as fully integrated.

Most of the companies in the partially integrated category readily admitted that their organization did not have a well-developed decision support link with their existing GIS. In addition to map production and inventory maintenance/update functions, the GIS was used for:

* Harvest Planning/Scheduling
* Forest Management Planning/Scheduling
* Strategic Planning

Almost No Integration. The three companies in this category were slightly more advanced in the development and use of their GIS than the next group. Two companies recently acquired a GIS through recent mergers and were heavily involved in digitizing the new land base, constructing the database, and learning how to use the system. These companies have fewer years of GIS experience (5.3); fewer number of GIS personnel (4); utilize both minicomputers (DEC PDP/11 and Data General) and microcomputers (Compaq 386); and use less powerful software (Comarc and GeoBased) than the companies in the previous categories. Map production and inventory maintenance/update were the primary uses of the GIS system.

No Integration. The last group of five companies have recently acquired a GIS and are just beginning to integrate this system with previously developed databases and decision support software. As expected, these companies are concentrating on digitizing the land base, building or integrating databases, and just beginning to develop decision support macros. The main characteristics of these five companies are an average of 1.2 years experience with GIS, a small staff of 2-3 individuals, and exclusive use of microcomputer-based hardware (Compaq 386, IBM PC AT, and other 386 compatibles) and software (PC Arc/Info, GeoBased, and InterCart). At least initially, map production and database maintenance/update functions will obviously take precedence over development of decision support applications.

HARVEST PLANNING DECISION SUPPORT SYSTEM

Since harvest planning/scheduling is typically one of the first applications developed by forest products companies, the remainder of the paper will describe a cooperative research project that developed a prototype decision support system for use in planning timber harvests. The objective of the research was to combine the spatial/database information contained in the GIS with OR/MS models designed to aid and improve the harvest planning process. Through graphical displays and printed tabular output, the decision support system identifies sites where mechanized harvesting systems can operate productively and with minimal environmental disturbance.

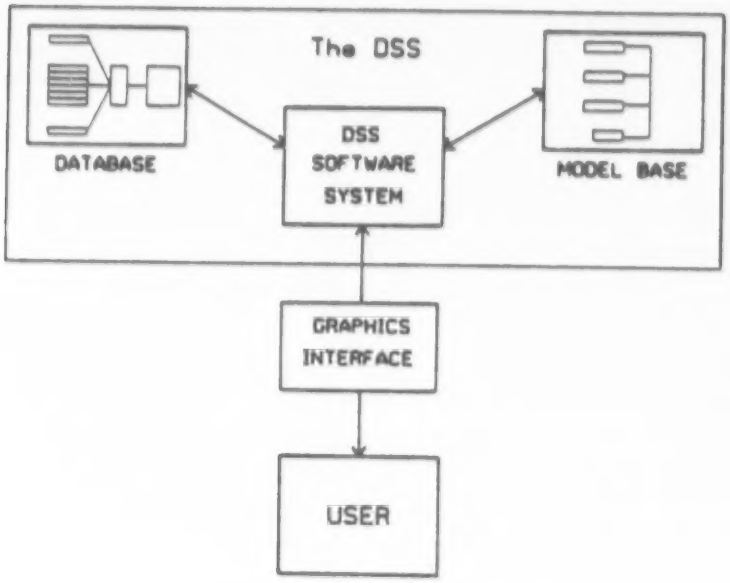
The Harvest Planning Decision Support System (HPDSS) is designed to help the user answer three questions:

1. Which stands should be harvested in order to meet annual mill wood requirements?
2. What is the "best" method of accessing these stands?
3. What harvesting equipment is best suited for harvesting these stands?

As illustrated in Figure 1, HPDSS consists of four separate but interrelated components:

1. the GIS/Database,
2. the Model Base,
3. DSS Software/ Graphical Interface, and
4. the User.

FIGURE 1
STRUCTURE OF THE DECISION SUPPORT SYSTEM FOR HARVEST PLANNING (HPDSS)



GIS/DATABASE

HPDSS utilizes an existing GIS maintained by Great Northern Paper Company (GNP) Millinocket, Maine, the cooperator in this research. GNP's database includes forest cover types, site classes, inventory data, cadastral information on company land, roads, regulatory zones, and information on past harvesting, silvicultural, and protection activities for 2.4 million acres in northern Maine. Terrain classification data on slope (i.e., digital elevation model data), ground strength, and surface roughness were added to a smaller portion of this acreage as part of this research (Reisinger and Davis 1986).

The database and graphic design files were developed on an Intergraph system consisting of a VAX 11-750 minicomputer, dual-screen color graphics workstation, digitizer, and plotter using Intergraph IGDS/DMRS software.

MODEL BASE

The model base component of HPDSS is composed of several mathematical programming models and heuristics that the planner can use to make decisions or to develop harvest plans. The data requirements for each model are determined by the DSS and then the data are retrieved from the GIS/Database. Separate models are employed for each of the three questions that HPDSS is designed to address: Stand Selection, Stand Access, and/or Equipment Selection.

A brief discussion of these three models follows. Consult Davis (1987) for a detailed discussion of the underlying model assumptions.

Stand Selection. The objective of the stand selection model is to determine which stands should be harvested in order to minimize "risk of fiber loss" (i.e., potential loss due to spruce budworm attack) (Boss 1985). User-supplied input constraints include yearly minimum harvest volume (by species). The stand selection model assumes that clearcutting is the method of harvest and that each stand is considered as integral units. Given these assumptions, stands are selected for harvest using a linear programming (LP) model, in which the objective is to minimize the sum of the risk ratings of selected stands while satisfying yearly volume requirements.

Stand Access. The objective of the stand access model is to determine the minimum cost location of "new" roads that must be constructed to access the stands scheduled for harvest. The user supplies road construction costs (per mile). The model assumes a stand is accessible if its centroid lies within 20-chains (1/4 mile) of an existing road and the only way to gain access to an inaccessible stand is through an adjacent accessible stand. Given these assumptions, stand access is determined using a weighted graph or network. The minimum cost road construction pattern is represented by the minimum spanning tree of the graph.

Equipment Selection. The objective of the equipment selection model is to determine the lowest cost "assignment" of harvesting equipment to stands scheduled for harvest. The user specifies the number of productive units (i.e. men or machines) available and terrain operating limitations for three types of harvesting systems (e.g. feller-forwarder, feller-buncher/grapple skidder, and manual-fell/cable skidder). Assuming that only one system may be assigned to a stand, the equipment selection model is formulated as an integer program, in which, the objective is to minimize total harvesting costs.

DSS SOFTWARE/GRAPHICS INTERFACE

The DSS software and graphics interface plays a major role in driving the HPDSS system. The user determines the decision module being considered and initiates the decision process through a series of tutorial screen menus and data prompts. The DSS software determines which models to utilize and then determines what data is required to execute that model. The graphics interface then displays a base map of the GIS and directs the user to delineate the area to be considered in the planning process.

The DSS software/graphics interface then acts as a linking device between the GIS and the model base. It issues database access commands to extract the relevant information about the planning area under consideration, and then initiates execution of the mathematical programming module or heuristic. After a solution has been determined, the DSS software graphics interface displays the results in map form and/or written reports.

THE USER

The final and most important component of HPDSS is the user. His/her judgment is essential to the decision-making process since many of the decisions made are complex and semi-structured. It is the user's responsibility to express the "unquantifiable" constraints that are imposed upon the problem and to incorporate them into the solution proposed by the DSS.

The typical procedure for decision-making utilizing HPDSS is an iterative process. The number of cycles through this iterative loop is controlled by the user. When the solution proposed satisfies the user's objectives, he/she can move on to the next decision module or exit HPDSS with the appropriate harvest decisions/plans. The base map of the planning area with the current solution is displayed for the user's review and acceptance. In addition to color fill graphical displays, HPDSS also provides the user with a series of printed reports/summaries that detail the economic consequences of these decisions/plans.

CONCLUSION

Even though the results of the forest industry survey are preliminary, several trends are apparent. To successfully integrate GIS with DSS requires (1) a long-term commitment of several years; (2) financial commitment for GIS/DSS development personnel and the hardware/software configuration capable of sophisticated analyses; and (3) management commitment, at all levels, to using the GIS/DSS system.

However, an integrated GIS/DSS approach offers several advantages over current methods of operating. It provides forest industry planners and managers with a more efficient means of evaluating the large volume of

diverse and site-specific data inherent in managing large forest ownerships. The DSS also provides an improved mechanism for incorporating mathematical programming models into the decision-making process.

As the HPDSS example illustrates, a well-developed DSS permits the user to incorporate his/her experience and judgment into the harvest plans developed. This planner-computer interaction allows for expression of "unquantifiable" constraints and results in a more realistic description of the planning problem. HPDSS utilizes graphics to present the results of the optimization and/or economic decision models. Since harvesting and forest management decisions are essentially spatial in nature, graphic displays of the planning area, combined with written reports, facilitate the planner's understanding and interpretation of the proposed timber harvest plans. The net effect of such an integrated GIS/DSS approach should ultimately lead to better timber harvesting and environmental planning.

REFERENCES

American Forest Council. 1988. **National Survey on Forest Management and Remote Sensing.** American Forest Council, 16 pp.

Boss, D.E. 1985. **A Cartographic Modeling Aid to Strategic Forest Planning.** Unpublished Master's Thesis, University of Maine, Orono, 150 pp.

Cowen, D.J. 1988. **GIS versus CAD versus DBMS: What are the Differences?** Photogrammetric Engineering and Remote Sensing 54(11):1551-1555.

Crain, I.K. and C.L. MacDonald. 1983. **From Land Inventory to Land Management. The Evolution of an Operational GIS.** Proceedings, Auto Carto VI, Vol. 1, pp. 41-50.

Davis, C.J. 1987. **Planning Timber Harvest Activities with Geographic Information/Decision Support Systems.** Ph.D. Dissertation, Forestry and Natural Resources, Purdue University, West Lafayette, IN. 249 pp.

Reisinger, T.W. and C.J. Davis. 1986. **A Map-based Decision Support System for Evaluating Terrain and Planning Timber Harvests.** Transactions of the ASAE 29(5):1199-1023.

Sieg, G.E. and M.P. McCollum. 1988. **Integrating Geographic Information Systems and Decision Support Systems.** Proceedings, GIS/LIS '88, Nov. 31-Dec. 2, San Antonio, TX, Vol. 2, pp. 901-910.

Wakely, R. R. 1987. **G.I.S. and Weyerhaeuser - 20 years' Experience.** Proceedings, GIS'87. Oct. 26-30, San Francisco, CA, Vol. II, pp. 447-455.

HIMALAYAN-SCALE PROBLEMS AND MICRO-GIS SOLUTIONS

H. Schreier, P.B. Shah***, M. Schmidt*, and G. Kennedy***
University of British Columbia, Vancouver B.C.
V6T 2A2

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

An integrated land resource inventory was carried out in Nepal under CIDA sponsorship and the resulting maps and data were found to be cumbersome and difficult to use for national and district level planning. A micro-computer based GIS system was introduced to process some of the resource data and a methodology was developed to assess resource issues at the district and watershed levels. Problems relating to forest degradation, fuelwood and fodder deficiencies, and maintenance of agricultural production were assessed and a model was developed to determine where fuelwood, fodder, and food deficiencies are most acute, how much land use change and forest degradation has taken place, and how GIS can assist in the afforestation program.

* Department of Soil Science, University of British Columbia, Vancouver, B.C., Canada.
** Deptartment of Agricultural Economics, University of British Columbia., Vancouver, B.C., Canada
*** Integrated Survey Section, Topographical Survey Branch, HMG, Box 1611, Kathmandu, Nepal.

INTRODUCTION

Land resource inventories have been carried out in many mountainous areas but there have been few successful applications evaluating the land resource data effectively. Major problems with such approaches are: integrating data sources collected at different times and at different scales, complex maps and legends with incomplete basic resource information, little interpreted evaluations, and presentation of results in a format not readily useful to land use planners and managers.

An integrated land resource inventory (Land Resource Mapping Project, LRMP 1984) was carried out in Nepal between 1979 and 1984 and upon completion of the survey many requests were received for basic resource information from Nepali government agencies, international organizations, and consultants. Each request had different priorities in terms of type of data, location, area, and format and with the available resources it became very tedious, time-consuming, and often impossible to properly respond to the different requests. In addition much time was spent explaining the mapping and survey system to the user.

To overcome some of these problems we introduced a PC-based GIS system (Terrasoft) and developed a methodology which facilitated the analysis and presentation of the available resource data according to individual requests. The national survey was carried out in an integrated manner and all basic resource information except geology was collected at 1: 50 000 scale. This simplified the digitization process and allowed the efficient production of portfolio maps. Introducing a PC-based system means that creating a digital national data base is out of the question, but this is in any case inappropriate at the present time, given the infrastructure in Nepal. Instead, areas and resources at district and watershed levels are being assessed on a demand or priority basis and since the technology is simple and robust it can be carried out with relatively little training and infrastructure support.

As shown by Thompson and Warburton (1985), Singh and Kaur (1985), Ives and Ives (1987), and Ives and Messerli (1989), resource sustainability in Nepal is a very controversial issue. Forests are used to sustain agriculture in many places and fuelwood and fodder demands are considered critical in many mountain watersheds. Experts have come up with contradictory results regarding the fuelwood and fodder supply and no overview exists to indicate in what districts the problems are most acute. The LRMP data can assist in this process and a model was first developed for the Jhikhu Khola watershed, and the Dhankuta district and is currently being applied to other areas in Nepal.

METHOD

The land use, topography, land systems, and land capability information was digitized using the 1:50 000 scale topographic map as a data base. The area covered by each polygon was determined with the GIS system and together with additional resource information was tabulated using spreadsheet and graphics programs. Aerial summaries of the biophysical data were determined for within watershed and district boundaries. The digital elevation data was used in conjunction with climatic information to arrive at a crude subdivision of micro-climatic conditions. Finally, the socio-economic, population and livestock data which were collected at the village and district level were also entered into the spreadsheet data base. This allowed us to present the spatial extent of each resource data set as an individual overhead or combination of data according to requests. A more detailed description of the methodology is provided by Schreier et al.(1988), and Shah et al. (1987).

Resource sustainability cannot be assessed in a static manner and land use changes were analyzed by comparing 1950 with the 1980 LRMP data. The dynamics of these changes were then displayed using the GIS and graphics programs. The program is being expanded to include such processes as soil erosion, sedimentation transport, and water balance in the Jhikhu Khola watershed where actual field measurements are being incorporated into a GIS model.

Finally, a spreedsheet model was developed to calculate supply and demand for such resources as fuelwood, fodder, and food. Trade and marketing was not considered in this model which can be justified given the type of subsistence agriculture which is practiced in the hill and mountain areas of Nepal. A systematic analysis is made of each district and the results will be portrayed with the GIS technique to show where resource sustainability is most critical.

RESULTS

With the GIS technique a complete set of resource portfolio maps were produced indicating the aerial extent and spatial distribution of forest type and major crop rotation systems. Single, double and triple annual crop rotations are carried out in most watersheds in Nepal and this is mostly dependent on availability of irrigation water during the dry season, topography and soil conditions. Using the digitized elevation data and the available climatic information, the watershed was then divided into elevation, slope, and aspect categories. This was done to arrive at a physiographic subdivision indicative of micro-climatic conditions within the watershed. The combined elevation/slope/aspect classes are now being calibrated using climatic information collected in the field. Crop and forest classes were superimposed on this topographic data set and this provides an assessment of what type of forest or crop is present at what elevation/slope/aspect conditions in the watershed. The actual distribution of forests and crops was compared with the land capability ratings to determine how well the current land use matches the capability ratings.

These combined maps are of interest in afforestation programs which are initiated in many parts of Nepal to overcome chronic fuelwood and fodder deficits. Tree seedling survival is a serious problem (Applegate and Gilmour 1987). Heavy grazing, difficult climatic conditions, and poor site and soil conditions are the main reasons for this difficulty. The elevation/slope/aspect map in combination with forest cover and capability can greatly assist in the afforestation program. It provides a crude basis for matching tree species with appropriate environments and new crops and cropping systems, such as fruit and vegetables with the most appropriate site conditions.

The second useful program was to evaluate land use changes with GIS. The LRMP data provided the basis for a quantitative analysis of the most recent land use. Historic land use data was then collected for the same watershed. The original 1:50 000 scale topographic map, which was produced around 1950, contains three land use categories which were defined a) dense jungle, b) shrubs with a few scattered trees, and c) agriculture. Although somewhat crude, this information was found to be very useful in producing a land use change overview map. The results provided in Table 1 showed the overall land use changes over a 30-year time span derived from the GIS analysis.

TABLE 1

OVERALL LAND USE CHANGES IN THE JHIKHU KHOLA WATERSHED BETWEEN 1950 AND 1980.

Land Use 1950:	Land Use 1980:	Area (ha)	% of Watershed
Agriculture	Agriculture	5378	38.3
Agriculture	Forest	454	3.2
Agriculture	Shrub	556	4.0
Forest	Agriculture	2058	14.7
Forest	Forest	2661	18.9
Forest	Shrub	2114	15.1
Shrub	Agriculture	369	2.6
Shrub	Forest	329	2.3
Shrub	Shrub	132	0.9

Land Use Change:

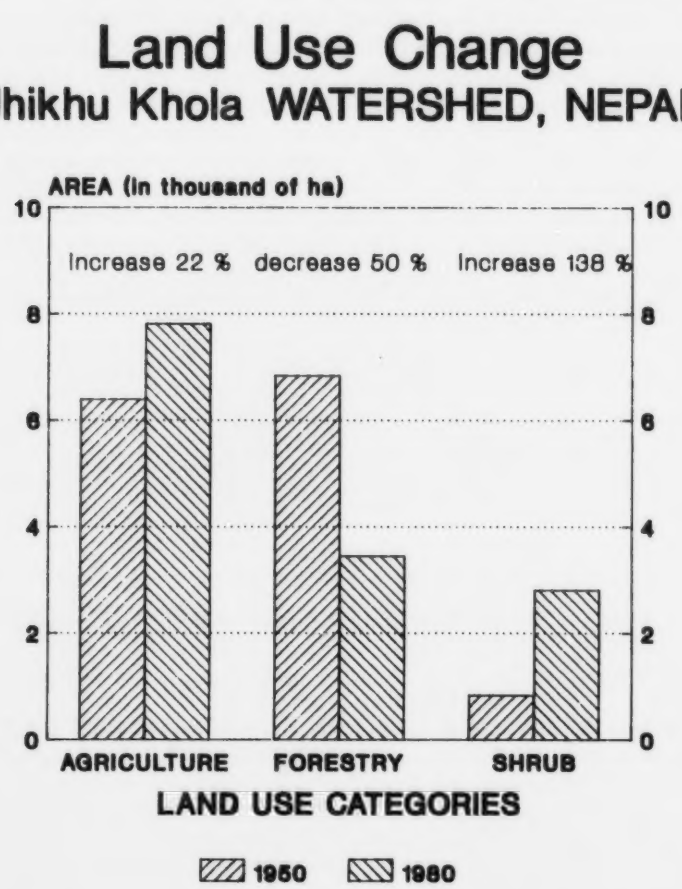
Agriculture	Overall Net Gain : 1417 ha or 10.0 % of Watershed
Forestry	Overall Net Loss : 3389 ha or 24.1 % of Watershed
Shrub	Overall Net Gain : 1972 ha or 14.0 % of Watershed

This data indicates that over the 30-year time span about one half of the forest land has been lost to shrub and agriculture, (Figure 1) suggesting a serious deterioration of forest conditions in the watershed. However, the dynamics of land use change need to be evaluated in smaller time increments since current efforts in afforestation are not evident in this data set. We have obtained 1972 aerial photographs for the watershed and this data source

will also be incorporated into the GIS data base so as to produce a more refined analysis of land use change. In addition, changes in the soil and water resources will also be incorporated into the model. Current water input and output, soil erosion and sediment transport are being measured at seven stations within the watershed and we anticipate using this data to arrive at a mass balance (input/output) and process evaluation of the critical resources.

FIGURE 1

LAND USE CHANGES 1950-1980, JHIKHU KHOLA WATERSHED



The third method which is showing promise is related to supply and demand analysis for fuelwood, fodder, and food at the district level. So far 9 districts have been analyzed and we hope to have the remaining 65 districts analyzed shortly. The GIS analysis provides aerial summaries of all the land use subdivisions such as forest type classes with different crown densities, or triple annual crop rotation (rice followed by corn followed by millets) on land classified as capability 2. These data were incorporated into the speadsheet and combined with the interview data file which contains the essential information on crop and forest yields, population and livestock distribution. Supply and demand calculations were carried out to determine excess and deficiencies at the district level.

Available consumption figures for food (FAO 1972), fodder and fuelwood (Brewbaker 1983) were used as guidelines for the calculations. An example of a district balance sheet is provided in Table 2.

TABLE 2
SUPPLY AND DEMAND BALANCE SHEET FOR FUELWOOD, FODDER, AND FOOD IN THE DHANKUTA DISTRICT IN NEPAL

Resource	Supply	Demand	Deficit Excess
Fuelwood (ADT) *	116,130	87,860	32.2%
Fodder (Tons TDN) **	63,140	86,650	-27.1%
Food (Mio K-cal/year) ***	117,280	98,640	18.6%

* ADT (Air Dried Tons), minimum requirements = 0.64 ADT or 1.07 m^3/person/year and 1987 population figures.
** TDN (Total Digestible Nutrients) from both agriculture and forestry, based on 1983/84 livestock data.
*** Based on 1987 population, 2700 cal/person/day requirements, 10 % of food requirements from livestock, eight major staples.

It reveals that the fodder situation in the Dhankuta district is most critical, while the food self-sufficiency is adequate. A number of assumptions were made in this evaluation and the ultimate aim is to produce such a balance sheet for all 74 districts in Nepal.

We do not claim that these calculations will give us exact values since the accuracy of our population and livestock data might be questioned. However, we hope to use the information to indicate to the Nepali government which district has resource sustainability problems and whether fuelwood, fodder, or food production needs most attention.

CONCLUSIONS

Micro-computer based GIS systems are proving to play an important role in third world resource development. We developed a GIS-based model which we used in combination with spreadsheet and graphics programs to evaluate agricultural and forestry re sources at the district and watershed levels in Nepal. The cost of this technology is low, the techniques are relatively simple, and the output products are dynamic and user friendly. In a very short period we were able to train Nepali professionals to:

1) Produce portfolio maps of the basic land resources at the district and watershed level,
2) Generate terrain divisions indicative of micro-climatic conditions using DTM and climatic data,
3) Create maps that combine several resources,
4) Evaluate land use change, and
5) Produce a supply and demand balance sheet for fuelwood, fodder, and food.

REFERENCES

Applegate, G.B. and D.A. Gilmour. 1987. **Operational Experiences in Forest Management Development in the Hills of Nepal.** ICIMOD, Occasional Paper No. 6. 40 pp.

Brewbaker, J. 1983. **Fodder and Fuelwood-N2 Fixing Trees for Nepal. IADS, Integrated Cereal Project.** Dept. of Agriculture, HMG. 18 pp.

FAO. 1972. **Food Consumption Tables for Use in East Asia, Food and Agricultural Organization.** FAO, Rome.

Ives, J.D. and B. Messerli .1989. **The Himalayan Dilemma.** Rutledge Press Ltd. London.

Ives, J.D. and P. Ives .1987. **The Himalaya-Ganges Problem.** Mountain Research and Development. Vol. 7: 181-344.

LRMP. 1986. **Land Resource Mapping Project.** Soils, Agriculture, Forestry, Land Use, Land Capability, and Economics Reports. HMG, Nepal and Canadian Government. 140 pp.

Schreier, H. M. Schmidt, R. Wiart, and P.B. Shah .1988.**Evaluating the Biophysical Resources in the Lhiku Khola Watershed, Using LRMP Data and Micro-computer Based GIS Techniques.** Final Report for Canadian International Development Agency (CIDA). 25 pp.

Shah, P.B., G. Nakarmi, A. Duvari, K. Tivari, B. Shrestha, and H. Schreier. 1987. **A Resource Evaluation of the Dhankuta District.** Integrated Survey Section, HMG, and CIDA. 66 pp.

Singh, T.V. and J. Kaur. 1988. **Studies in Himalayan Ecology and Development Strategies.** Himalayan Books Ltd. New Delhi. 325 pp.

Thompson, M. and M. Warburton. 1985. **Uncertainty on a Himalayan Scale.** Mountain Research and Development, Vol. 5: 115-135.

Financial support for this work has been provided by CIDA (Canadian International Development Agency, Ottawa) and IDRC (International Development Research Centre, Ottawa). A special thank you goes to R. Wiart (B.C. Ministry of Forests) and S. Brown (UBC-Soil Science) for their help in getting the computer system and training program operational, and to all the members of the Integrated Survey Section HMG, in Kathmandu, who helped with the data compilation.

THE ULTIMATE COMPROMISE:
SITUATING GIS IN THE ORGANIZATIONAL HIERARCHY

James L. Smith, Associate Professor
Stephen P. Prisley, Research Assistant

Department of Forestry
Virginia Polytechnic Institute
Blacksburg, VA 24060
(703) 231-7811

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Natural resource organizations typically have a hierarchical management structure with widely different goals inherent at each level. GIS could reasonably be placed at any management level, with associated advantages. The placement at any level also has disadvantages, so all placement decisions are, in effect, compromises. These issues will be discussed and considered in light of changes in machine, software and organizational environments which have occurred over the past few years.

INTRODUCTION

As researchers at an educational institution, our work emphasis by default is often on what we might call "technical issues", you know, the speed, accuracy, or functionality of GIS. However, our experience is that what we might call "management issues" are often paramount; considerations such as personnel, control, coordination and allocation of resources may determine the usefulness of a GIS more than the number of layers of data it can handle. While we are not management experts, our experience and contacts with operational users of GIS have helped us gain some insight into these issues.

This article is, in effect, an update of one we presented at GIS '87 in San Francisco (Smith and Prisley 1987). Our intent here is not to repeat, but to discuss issues raised in that paper in light of the changes which have occurred in the hardware, software and organizational environments. Thus, a short summary of salient points from the original article is appropriate.

SUMMARY OF 1987 PAPER

Large forestry organizations typically have a multi-layered hierarchy, with the most common structure exhibiting three levels of management. These levels of hierarchy have differences in responsibility created by the unique characteristics of the forest management process. The basic raw material (forests and trees) is of relatively low value per unit area, is geographically dispersed over large regions, and the resource often has diverse characteristics which require that procedures change by locality.

We called the three management levels of the typical forestry organization the Area, Region and Division. At the Area, the major function is resource management. Here, day-to-day, site-specific decisions are reached and carried-out. The most current, complete and detailed information is needed at this level. The Region is a transitional level between the "corporation" and the "forester." The major function of personnel at this level is coordination and control. This level of management is responsible for interpreting and implementing strategic decisions reached at the Division level. At the Division level, site-specific information is virtually unnecessary because the major responsibility here is policy, not land management. Currency and detail in data are typically less important because global decisions are made here, not site-specific ones.

The question then becomes which is the "best" level for GIS? Of course, the answer will vary according to the definition of "best." Best could mean cheapest, or most often used, or most appropriately used or something else entirely. The conflicts which most often arise are between cost, data control and data accessibility. Cost would generally be cheaper with a single, corporate wide system, but in this case, the spatial nature of the data is almost unnecessary, and will likely go largely unused. Data security would also be greater for a single "corporate" data base, but again, the data would almost always be aggregated before it is used at the upper levels of management. The data would rarely be used for site-specific decisions by foresters because it is too troublesome to reach. At the other extreme, if a GIS is placed in each Area, system costs will likely be higher, and control of the database becomes difficult. However, the data as stored by the system is at the proper level of resolution, and the true power of a GIS is most useful at this level of management. Thus, data control and data access cannot both be maximized. A decision to place a GIS at any hierarchical level is a compromise. The easy and safe decision is thus to put the GIS in limbo, middle-of-the-road, in-between, e.g. the Region. This seems to have been the most popular choice among the early users of GIS technology.

UPDATE

The issues discussed in the 1987 San Francisco paper are basically still pertinent in 1989. Changes in the GIS environment have not eliminated the conflicts which typically arise in a multi-layered organizational hierarchy. However, the way in which the conflicts are resolved has undergone a subtle evolution. We will describe three broad categories of change, the machine environment, the GIS software environment and the organizational environment.

MACHINE ENVIRONMENT

As a whole, the "machine" environment has seen the most change in the past two years. By machine, we mean any hardware or background software required by a GIS, for instance, CPU, graphics device, plotter, operating system and networking software. In almost every case, power or capability per unit cost has increased, often dramatically in great leaps of development. Everyone knows that personal computers and workstations are proliferating as the demand for individual computer power grows. In addition, examine the case of color graphics devices. In 1982, a Jupiter terminal cost approximately $10,000. Today, sufficient graphics capability for most GIS-type analyses can be purchased for less than $1000. Plotters have increased in speed and function, and less expensive versions are available for tasks which require less precision or smaller map format. In short, a wide range of devices is now available; some are big, some are small, some are expensive, some are cheap. The result is flexibility.

Of particular importance to the problem of providing flexibility in the placement of GIS in the management hierarchy is the fast pace of development in the networking industry. Rapid telecommunication of data is very important to forestry organizations because of the size and geographic extent of their basic data. Fortunately, communications between machines is perhaps the hottest topic in the computer industry today. A casual glance at Byte, Personal Computing or Digital Review will confirm this assertion. Virtually any computer can send and receive data to and from any other, regardless of brand or distance. The development of networking protocols such as OSI and TCP/IP have helped spur the interest of GIS hardware and software vendors. Again, the result is flexibility. It is now possible to widely distribute or disperse data and processing power, and yet maintain some contact and control. The gap between data control and data accessibility has thus been at least partially bridged.

GIS SOFTWARE ENVIRONMENT

The vendors of GIS and related database software have responded in kind to developments in the hardware environment. As the power of personal computers and super-micros increased, they became the machine-of-choice for developers of software. Witness the number of GIS packages for Apple, IBM and IBM-compatible machines introduced or converted in the past two or three years.

This development at the lower end of the spectrum has created a market for networking capabilities as well. In the early years, the decision to place GIS at the mid-level of the management hierarchy was in large part due to the cost of the computing and peripheral equipment needed to operate a GIS. It was not feasible to spend $100,000 for hardware at each of the lower nodes of the hierarchy. Now that the hardware costs are feasible, the data control issues typically stressed by those at higher levels of management become paramount. At least two of the major GIS/LIS software vendors have responded by developing subsystems which can run on personal computers or workstations that are upwardly compatible with the mini-computer system: Distributed VAX Center (DVC) by Synercom Technology, Inc. and pcARC/INFO by ESRI. With these systems, it is technically feasible to maintain a centralized database linked to satellite work sites which have the ability to store, manipulate and update portions of the overall database. Thus, database control and security could be maintained at a higher organizational level through well defined and strictly implemented procedures, while those at the lower management levels who need the data most have direct access to the required information. Again, neither data control nor access is maximized, but the problems resulting from these fundamentally conflicting objectives have been mitigated to some extent.

It is appropriate here to discuss the issue of dispersed versus distributed data bases in reference to forestry organizations. As defined by Seaborn (1988), a dispersed database is one in which individual pieces of the database are resident at different locations, and, each piece is unique and complete for that location. In contrast, a distributed database is also segmented by location, but in this case, other locations may need to access data housed elsewhere. An example of a distributed situation is a municipal database. The roads department may control the roads database, but the sewer department may need access to the roads information for their work. The distributed situation is much more complex than the dispersed, mainly because of the need to strictly define and enforce data access. Who owns the data, and who rents it? Fortunately, it seems that the situation in forestry can be considered to be dispersed data, not distributed. Each level of the management hierarchy is defined by a

unique geographic location, and the function is the same at each location. Thus, the only need for "outside" access to the data for each location is up the hierarchy, not across to other locations. The access problems are limited by this structure, but not eliminated. The result of this is that it may be easier to put the basic data in the hands of the user in forestry organizations than it will be for those organizations exhibiting a true distributed data structure.

ORGANIZATIONAL ENVIRONMENT

There have been many changes in the organizational environment which affect GIS implementation and utilization. Of most importance are evolving objectives and needs, and the changing awareness and knowledge of employees.

Initially, GIS were typically viewed as map-making systems which could overlay maps and compute proximity zones. However, more organizations are recognizing the potential of true spatial analysis, and the effect spatial analysis can have upon the actual management of their resource. This is not entirely voluntary, however, as environmental constraints tighten and the public becomes more aware of and involved in environmental issues. Ready examples of this are many, such as the proposed Best Management Practices (BMP's) for lands in the Chesapeake Bay watershed, and the continual litigation over the long-range management plans of U.S. national forests. These large-scale issues will impact site-specific land management decisions, creating the need for more detailed and complete data at that level of the hierarchy. This need is beginning to outweigh the data control and cost issues. Originally, despite intentions otherwise, the placement of GIS often made it more of a strategic planning tool than a land management tool. Now, information requirements for land management are subtly changing the way GIS are used.

A change in the nature of the personnel at the lower levels of the hierarchy has also impacted GIS plans for many forestry organizations. Graduates of the 1980's are cognizant of the power of computers, and even forestry graduates can write programs and use "canned" packages. Pressure for access from below is being heard by upper level managers. This new excitement and awareness has advantages and disadvantages, however. While foresters may now be more ready to use the new technology, their knowledge may encourage them to "tinker" with the system if given too much access. Controls on the data and the software may be more important now than ever. Also, foresters may have become spoiled to some extent by computer technology. They may want to use GIS as a substitute for field work, or for their own brain. Another danger is that the users may fail to examine or question the quality of the data they utilize because it came from the computer. Finally, GIS may have unreasonably raised the expectations of personnel at all levels of management. For instance, a few years ago a standard data base query over a large acreage would have taken days to perform by hand--tedious hours of examining paper reports and collecting information. Today, someone complains if the computer takes 10 minutes to perform the same operation. Speed should not be the driving issue in any GIS operation. Only rarely is immediate information needed in an organization where the resource, planning and manufacturing cycles are measured in decades.

SUMMARY AND CONCLUSIONS

How has the environment for GIS changed? In actuality, the issues which drive the placement decision have not changed much at all. However, the solutions to the conflicts have changed, and the conflicts themselves have evolved into a new form.

We believe that the key word today is flexibility, and that the flexibility of the GIS environment has increased dramatically in recent years. Decreases in hardware cost, and increases in machine power and networking capabilities will greatly impact the decision on where to place a GIS in the management hierarchy. However, these technical advances do not completely eliminate the management problems, they only give us choices where no choices existed before. It is now possible to put information at the lower levels of the hierarchy, while maintaining contact and control with it. Further, there is increasing awareness that the true power of a GIS increases as you proceed downward through the management hierarchy, and that the personnel exist at that level to put it to good use.

Thus, all signs, both technical and managerial, point to the migration of GIS downward from the middle to the lower hierarchical levels of management. This is certainly a change from the early years of this decade. While we believe that this is entirely appropriate, caution is advised. Caution is advised because the problems of management are not abated by this strategy, and in fact, may be exacerbated. For instance, how do you insure that proper backup procedures are followed? How do you insure data consistency and compatibility across the various localities? How do you encourage use of the systems, but discourage unapproved modifications? Lastly, how do you instill a sense of "stewardship" of the data in users, without creating a feeling of ownership and possessiveness?

We conclude with two suggestions:

> We request that GIS and related software vendors pay more attention to data management issues. A suggestion is to provide a facility similar to "transaction posting" which has been in use in accounting systems for years. This would allow a central data base manager to better control the updating process.
>
> We also request that more attention be paid to management issues in research agendas, publications and professional meetings. Where do practitioners go in general to learn from others mistakes and successes?

Positive responses to these two suggestions will help to remove the last major barriers to the placement of GIS at the lower levels of management, where it actually belongs.

REFERENCES

Seaborn, D.W. 1988. **Distributed Processing and Distributed Databases in GIS-separating Hype from Reality.** GIS/LIS '88, San Antonio, TX. pp. 141-144.

Smith, J.L. and S.P. Prisley. 1987. **Positioning GIS in the Management Hierarchy: the Forestry Experience.** GIS'87, San Francisco, CA. pp.38-45.

INFORMATION SYSTEMS: A FOREST PRODUCTS PERSPECTIVE

William D. Thomas

Director,
Millwide System Studies,
H.A. Simons Ltd.,
425 Carrall Street,
Vancouver, B.C. V6B 2J6

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

There are significant differences between conventional large-scale, well-ordered Management Information Systems/Data Processing systems and the new innovative world of "end-user" computing. This new user-intensive computing which is often microcomputer based can be broadly classed as applied technology. The two worlds of applied technology and MIS are planned for separately. This results in managers having two sources of system support which are usually incompatible. The experience of HA Simons in marrying applied technology in sawmills and pulp mills to traditional MIS systems may have parallels in designing GIS for forestry.

1. INTRODUCTORY REMARKS

At just about every major forestry conference there is a token computer system session, and some speaker re-telling the tale of the digital promised land. Perhaps the "techies" have talked about the subject too much without adding greatly to a consensus view of what computer systems really are in management terms. Perhaps too many vendors -- and consultants -- have volunteered their subjective views, and opportunistically use the latest fashion as a strategy to "move the iron", or move the man-hours.

Certainly computer people have a good technical grasp of systems and their integration, and our vendors are providing an ever more impressive array of innovative products: A veritable "minestrone" of computers which are usually difficult, -- if not impossible to interface with each other -- decorate most of our operations.

In pulp and paper industry production managers have generally been slow; however, to take the appropriate leadership role in defining, justifying, and introducing systems planning in their companies -- and perhaps GIS 89 is the most appropriate forum to address this problem.

For the problem is a management one, more than a technical or computer problem.

In both discrete and process manufacturing industries, we seem slow to grasp the real purpose and urgency of automation. And despite North America's expenditure in 1988 of $17 billion on computers, systems, and process control equipment, North America still lags behind Japan, Britain, and France in productivity growth -- the lever of economic growth.

A recent issue of Business Week carried a cover story on **The Productivity Paradox** -- an article which every manager might do well to read -- and absorb -- and it seems that increasingly the impediments to effective investment and implementation of "Applied Technology" are seen to be in the prosaic areas of cost accounting, management planning, and other low-tech but vital management roles. The realization of this in Japan and other countries is, perhaps, the reason why the Japanese industrial miracle took place, and even more worrying, why the Europeans are now integrating new factory technology at four times the pace of U.S. industry -- even faster than the Japanese.

So it is time for management -- get seriously involved with the implications of computer systems.

Too often management seems to duck its responsibility to provide the leadership necessary to bring about the difficult changes required to take advantage of the information age.

Our concern for the pulp and paper industry derives from the experience in the American automotive industry where, for too long, Deming was ignored and the implementation of robots integrated with information systems was deferred as being too "Buck Rogers" for our factories. If a difficult lesson was learned in the late 70's and early 80's in "Smokestack Industries", or perhaps "Exhaust Pipe Industries" -- I would hope we could apply this lesson to "Treestump Industries". There is no place for hesitance in the planning for an implementation of well proven and newer technologies if we wish to remain competitive in world markets.

We, at Simons, design and build pulp and paper mills all over the world. The majority of our work is in Canada and the United States, of course, but we also work in this industry in places ranging from Australia to Chile, to Czechoslovakia, and, I can assure you that the direct involvement and leadership of mill management in Millwide Systems is a major concern with the most successful companies.

Systems and applied technologies have been extensively used within my own company and they have profoundly changed the way we work. But it was a tough sell to some conventional consulting engineering managers who would prefer to leave the hard work of change to the "techies" or to the next generation of management.

Increasingly when discussing computers, great emphasis is put on the area of "communications" -- which usually refers to "data communications" in complex networks of mixed-vendor control and information systems.

Another kind of communications is also necessary if we are to enlist the required support of management from all sectors of our industry, and at Simons we have developed a fairly trivial model to facilitate this "human communication" of the concept of integrating different fields of endeavor and, indeed, different cultures found within our companies. I will now deal with a series of slides to illustrate this simple conceptual model and perhaps

clarify some of the issues in our role in millwide automation and some of the impediments and organizational polarities which interfere with its implementation, and how this can be applied to Geographic Information Systems.

2. MILLWIDE SYSTEMS - A DEFINITION

The series of illustrations which follows is useful in setting the context in which we use the term - Millwide Systems (MWS). Equivalent terms like Computer Integrated Manufacturing (CIM) and Integrated Plant Systems (IPS) are sometimes used interchangeably, but all refer to the combination of integrated process control and management information systems.

These expressions are so general in nature that a specific mill must define them in meaningful terms for its own situation. In some mills, emphasis is on process data acquisition through interconnection or networking of current and proposed process, control systems so that process information is available to all areas in the mill. In other cases, early emphasis is on integrating management systems with process control systems in one area of a mill. An example of this is the integration of production scheduling and shipping/invoicing systems with roll handling and paper machine control systems.

Full MWS consists of both of these steps -- and involves the technical challenge of networking all process control systems, and the management challenge of making effective use of the resulting wealth of shareable data. Interfacing the "systems engineer's" world of process control, applied technology (AT), with the "systems analyst's" world of management information and data processing (Management Information Systems (MIS)), is the goal of a millwide system. Before this can occur, a rational and coherent networking of all equipment must be planned and implemented.

Skills in process control and systems engineering must be interfaced with skills in MIS and data processing, and the MWS evolution must be guided by a clear plan and management direction.

The following illustrations expand on these points:

FIGURE 1

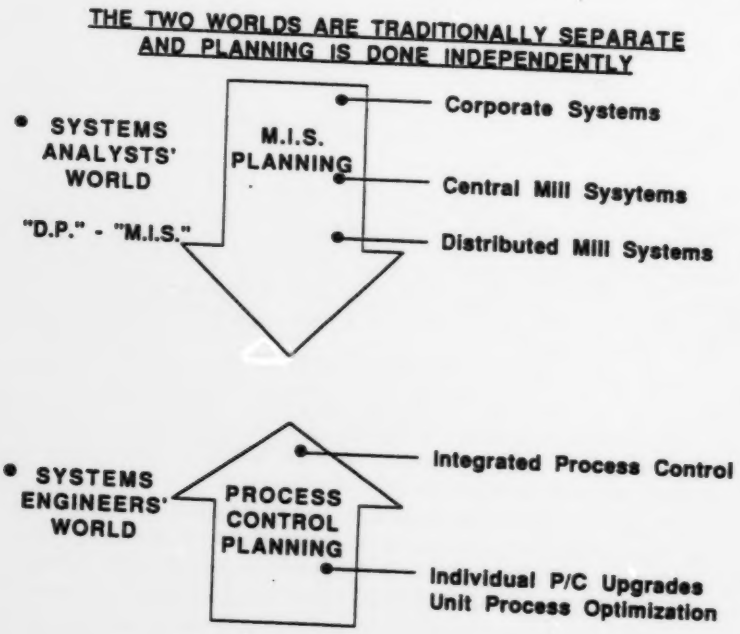


Fig. 1 illustrates the traditionally separate worlds of Management Information Systems and Process Control Engineering. The MIS function within a pulp and paper company is usually located centrally at a corporate office, performing data processing services for a number of mills at different locations.

Corporate System (e.g., finance, accounting) are run centrally for all mills in addition to certain common Mill Systems (order entry, production performance, etc.). Often, the central host computer communicates with local mill data processing computers. This has been an increasing mode of operation with lower cost processors providing effective distribution of mill systems to the mill sites.

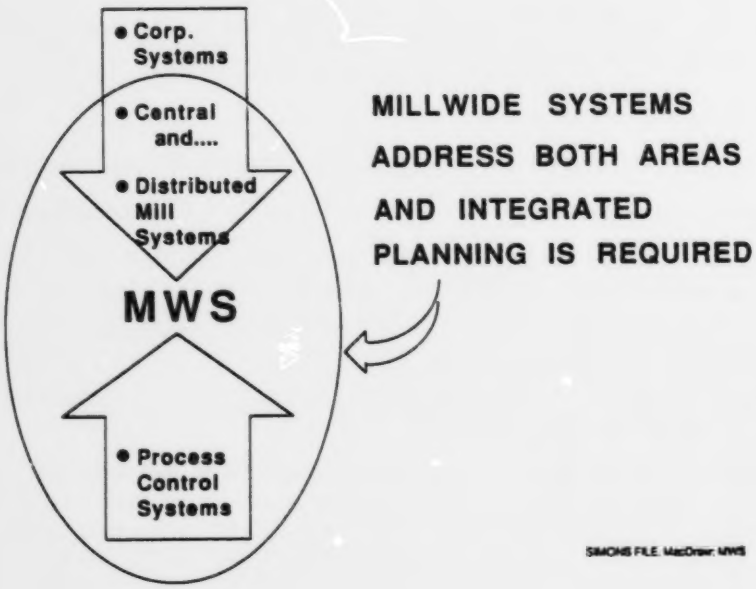
Within the mills, an increasing use of process control computers is common, and for the most part, these devices are planned for and installed with little or no coordination with MIS (either central or local).

The two worlds are planned for separately and the mill manager has essentially two sources of systems support, usually incompatible.

A Mill Wide system addresses both worlds, and integrates the mill process control systems with all MIS systems, whether run locally (distributed processing) or centrally (on corporate host machines). Mill management systems can then be designed which make use of both process and business systems data.

Fig. 2 illustrates the required boundary of a Mill Wide System - encompassing both the world of the system engineer in the mill, and the world of the systems analyst at local and central data processing locations.

FIGURE 2



A company's system can be divided into three categories: -

- Data Processing systems which support the basic business functions of finance and accounting (accounts payable, receivables, general ledger, etc.).
- More complex MIS systems which support the company's root business. These are industry specific and typically run on large mainframe computers or distributed mill data processing modes.
- Increasingly the growing field of Applied Technology and the advent of the "computer literate user" is leading to more systems which are outside the control of the MIS function. Examples of this would include work processing in offices, robots and CADD in discrete manufacturing, and process control computers in process industries.

The first two categories, DP and MIS, are characterized by a well-ordered operating environment usually supported by a single vendor (IBM in most cases) and are managed by the company's MIS function. The third category (AT) is characterized by many small limited function machines, from many vendors. They are usually innovative, user-controlled systems, and the personal computer or "Micro" explosion is rapidly causing this area to expand. This is illustrated in Fig. 3.

This general model can be applied to any industry. In a consulting engineering company, the model is illustrated in Fig. 4.

FIGURE 3

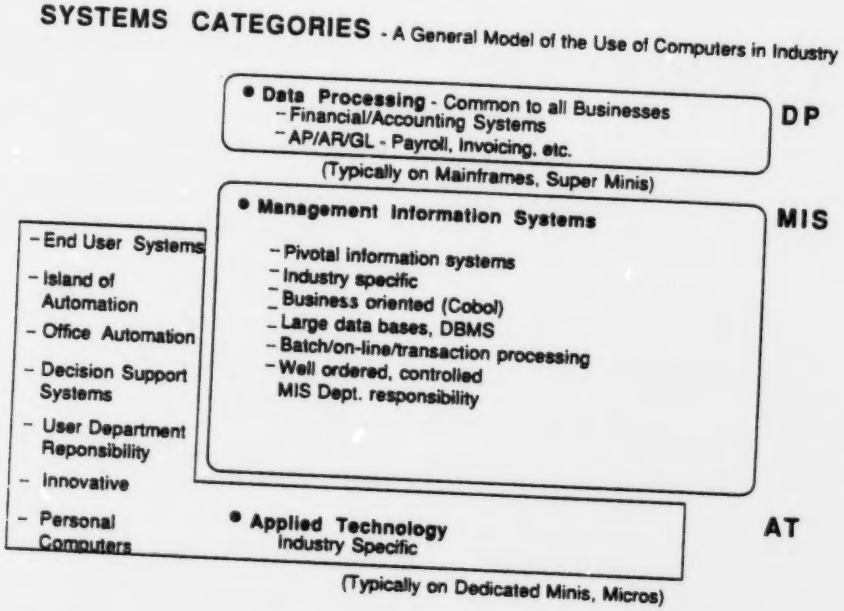
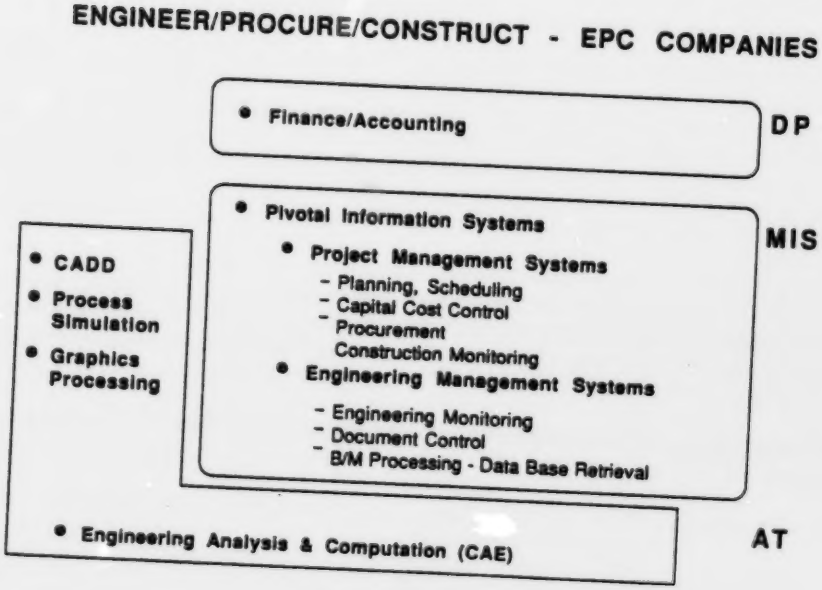

SYSTEMS CATEGORIES - A General Model of the Use of Computers in Industry
• Data Processing - Common to all Businesses
- Financial/Accounting Systems
- AP/AR/GL - Payroll, Invoicing, etc.
DP
(Typically on Mainframes, Super Minis)
• Management Information Systems
MIS
- Pivotal information systems
- Industry specific
- Business oriented (Cobol)
- Large data bases, DBMS
- Batch/on-line/transaction processing
- Well ordered, controlled MIS Dept. responsibility
- End User Systems
- Island of Automation
- Office Automation
- Decision Support Systems
- User Department Reponsibility
- Innovative
- Personal Computers
• Applied Technology
Industry Specific
AT
(Typically on Dedicated Minis, Micros)

FIGURE 4



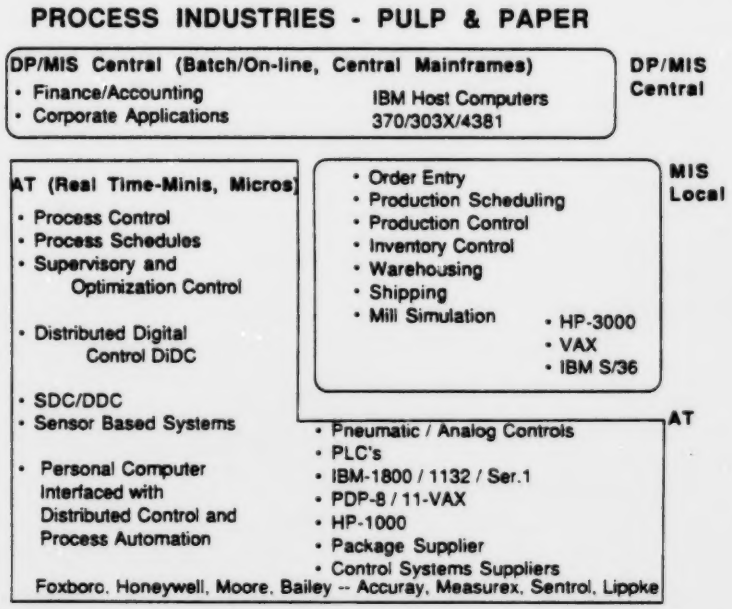
Like all businesses, an engineering company must support its payroll, labour distribution and other accounting applications with data processing.

The MIS functions in our engineering company tend to deal with client project management applications and internal pivotal control systems specific to this particular industry.

The newer, end user systems, outside the control of MIS, address engineering computation, simulation and, perhaps, computer aided design and drafting. Integrated systems require that the AT world of end user systems communicate with the more structured world of MIS and data processing. Computer Integrated Engineering (CIE) would imply that graphics systems, mathematical systems and management systems all communicate with each other.

In process industries, the general model can illustrate the relationship between process control functions and mill information systems (Fig. 5).

FIGURE 5



For instance, pulp and paper companies usually run both data processing and some common mill MIS applications on large central host mainframes at the Corporate offices. Individual mill MIS systems are usually run on local business processing computers at each mill; with telecommunication links back to the central host.

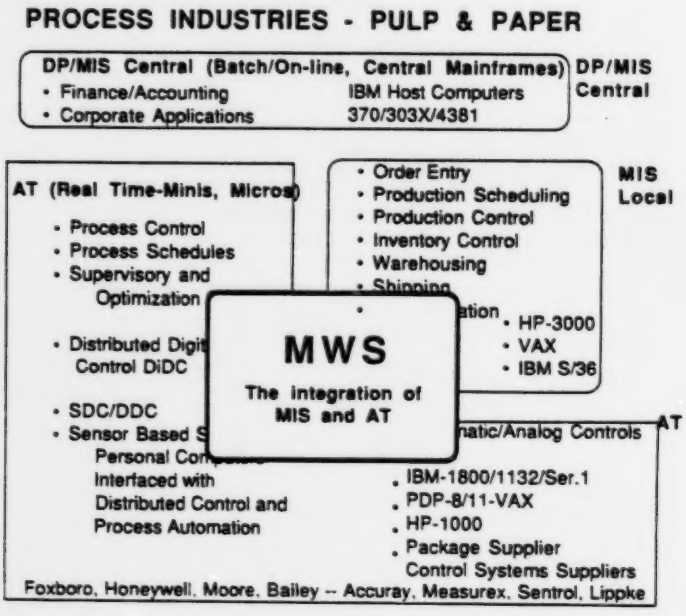
Central and local MIS systems are well controlled and run on one vendor's equipment as a rule (2 of 3 vendors are sometimes used).

In the area of Applied Technology, however, it is not unusual to find 5 or 6 independent (and often incompatible) systems supporting the complex requirements of sensor based systems. Well established process automation is very common in the pulp and paper industry, but integrated process control is relatively rare. The further integration of process control functions with MIS is even rarer.

The integration of the MIS systems with process control systems is required if the mill manager is to have access to complete data on his mill operations and performance.

A Mill Wide System (MWS) is then defined as one which provides for the integration of process data with business data. Mill management applications which require input from process control computers and MIS computers can be developed to better manage the mill. (Fig. 6)

FIGURE 6



Interface between different process control functions, and between these and MIS functions, must be developed and a coherent network plan must be initiated to provide for future additional systems.

The model can be applied to woodland management in a similar manner. Woodland management require the usual accounting functions of any business concern with appropriate data processing

Their MIS systems typically address woodlands support functions including inventories, stock and stand tables, regeneration, and cutting compliance monitoring.

In forestry operations, there are often a number of functionally separate systems sometimes referred to as "islands of automation". Typically, surveying and CAD applications are purchased from different vendors, and the AT world has difficulty communicating with the up-stream management systems. (Fig. 7)

Clearly, links must be established between MIS and the functionally isolated AT systems, as in the example illustrated. If the cut block is to indicate the volume of timber, it must be linked to timber inventory. Similar links must be established in many areas.

A definition of GIS emerges from our model as illustrated in Fig. 8. The first step to integrating the MIS and AT areas is to work on integrating the various elements within AT; such that functions in the woodland can communicate with one another. "Causeways" between these "islands of automation" must be built, and the somewhat disorderly world of end user (AT) systems must introduce some of the discipline and compatibility found in the MIS and DP areas of the company.

When this is accomplished, the full integration of end-user applied technology with management information systems is possible, and the goal of GIS is achieved.

GIS is the result of marrying the "forestry support" systems with the up stream management information systems.

FIGURE 7

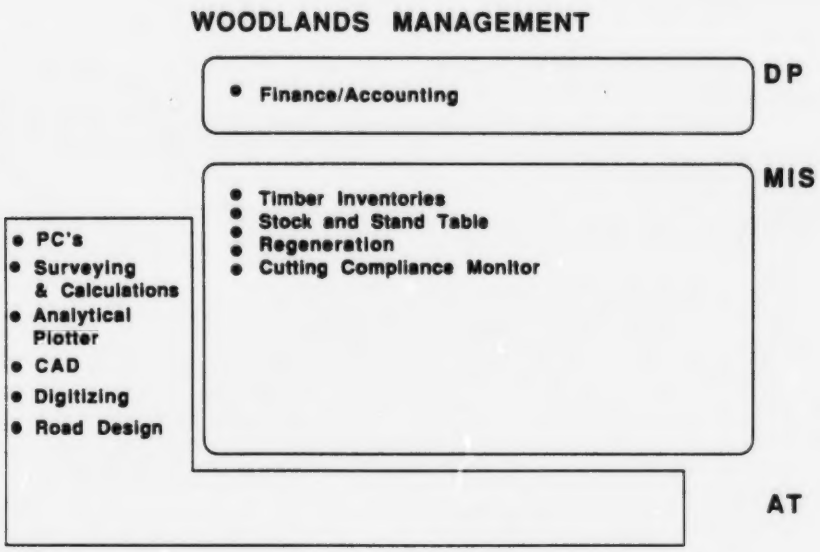
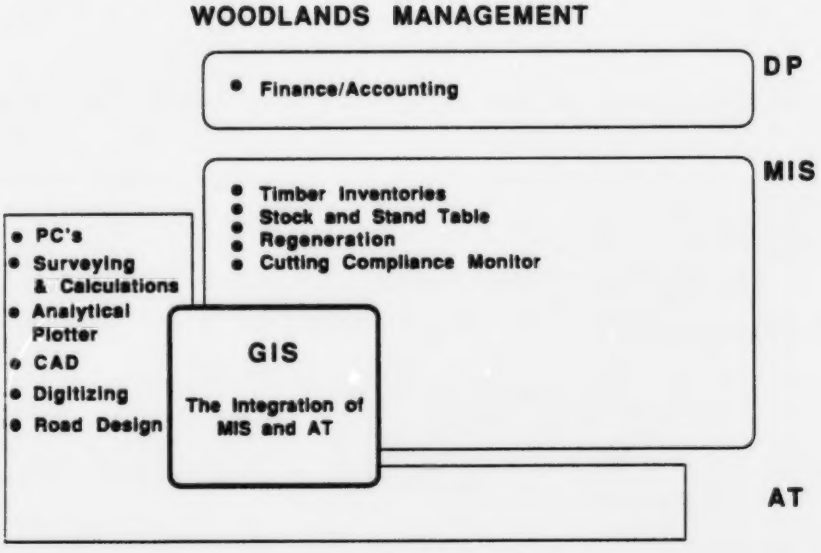


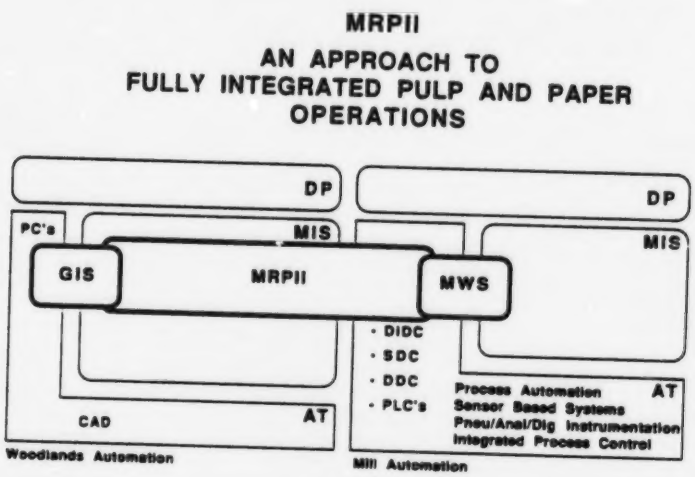
FIGURE 8



GIS and MWS are really the same thing - with the former applying to woodland automation and the latter to mill automation.

The final step is to link GIS and MWS systems together to achieve full corporate integration from the forest resource to the delivered product (Fig. 9). This allows the tracking of the tree's dis-assemply and re-assembly according to the requirements of the market place.

FIGURE 9



3. CLOSING REMARKS

Woodland management's role in Geographic Information Systems is, to recognize that it is your responsibility to plan it, to sell it to your funding sources, to implement it, and to facilitate change as necessary after implementation.

You need to understand **what it is.**
You need to know **why you need it.**
You need to know what the roadblocks are and understand the organizational polarities which cause these roadblocks.
And you need to seize the upper hand and assume the responsibility for leadership.

Rather than have vendors, consultants, and even your own "techies" lecture **you** on what Georaphic Information Systems are, you need to be telling **them:**

What it is
Why you need it
How you are going to control it

and set about solving the management and cultural problems which are the real impediments to its adoption.

In terms of the emerging international economic realities, it is your corporate responsibility to become intensely involved.

GIS IN THE NORDIC COUNTRIES
Market and Technology
Strategy for Implementation - A Nordic Approach
Applications of GIS to Forestry and Natural Resources - Norway

Svein Tveitdal

VIAK A/S Bendixklev 2
4800 Arendal, Norway
Tel: 47-41 25014

Olav Hesjedal

Institute for Environmental Analyses
3800 Bo, Norway
Tel: 47-3-950499

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

This paper covers GIS in planning and administration in Norway, Sweden, Denmark and Finland; application of GIS to forestry and natural resources; GIS systems developed in the Nordic countries vs. technology purchased from U.S. and Canada; export of GIS technology and expertise; strategies for implementation of GIS with focus on costs and benefits based on experience from the Nordic countries.

1 GIS IN THE NORDIC COUNTRIES - MARKET AND TECHNOLOGY

1.1 Background

The Nordic Countries - Denmark, Finland, Iceland, Norway and Sweden - have, due to their large areas of land and high emphasis on rural and urban planning, built up a high capacity in traditional map production. The tradition of keeping registers of land records dates back to the end of the 15th century. This tradition continues with the advent of computerized geographic information data bases. In 1986 at least 20 000 people from national institutions, municipalities and private industry in the Nordic countries were working with production of maps and spatial data. The value of this production was estimated at $ 900 million yearly.

The work with digital map information started in the end of the 1960s, and today there is a fast-growing market for the use of GIS in the private and public sectors. At the start, most applications were connected to facility management and administration of properties. But for the last few years we have seen a fast-growing use of GIS in physical planning, management of forestry and natural resources as well as environmental data.

Each of the countries has, through the national survey departments under establishment, national geographical data bases containing a growing number of map themes. In the next decade a majority of the 1 467 municipalities in Norway, Sweden, Denmark and Finland will have introduced GIS technology as a necessary tool to obtain increased efficiency mainly in the technical sector. On this background a number of Nordic private companies have developed systems and built up expertise to serve the domestic and international market with equipment and services in the GIS sector. The value of Nordic GIS exports is today in the range of $40 million yearly including systems and services. The development is supported from national research funds.

In Norway, digital geographical information is one of four areas with highest priority under the national research programme for information technology with a yearly budget on $ 120 million. In Sweden, an R & D Council for Land Information Technology (ULI) was established in 1986.

Below we present some figures on the market for GIS systems in the Nordic countries in 1988, as well as estimated market share between Nordic and USA/Canadian systems which together dominate the market. Please note that the figures given are for systems deliveries only (hardware/software). The growing market for technical, organizational and financial services as well as training and education connected to GIS implementation is not calculated. For some of the countries the figures are based on very limited market research and might therefore have limited accuracy. The total marked for GIS systems in the Nordic countries in 1988 is estimated at $ 37 400 000 of which approximately 50 % was delivered from Nordic manufacturers and 40 % from USA/Canada (mainly USA).

TABLE 1

THE GIS MARKET IN DENMARK, FINLAND, NORWAY AND SWEDEN IN 1988.
FIGURES IN 1000 $.

SYSTEM		DENMARK	FINLAND	NORWAY	SWEDEN
NORDIC		2 600	3 300	9 000	4 600
USA/CANADA		2 600	3 300	1 500	7 500
OTHERS					3 000
TOTAL	37 400	5 200	6 600	10 500	15 100

1.2 Denmark

The GIS investments in 1988 were $ 5 200 000 of which 50 % were Danish systems. The main Danish system is Dangraf which is developed in a joint venture of Kommunedata, Jydsk Telefon and Kampsax Data. The system is today running on PRIME computers but is now converted to IBM 6150. Main installations are by private

companies in photogrammetric map production, municipalities and utility agencies. Dangraf have also some installations in Sweden. Other Danish systems are OC-graf developed by OC Engineering based on Auto-Cad and running on IBM 386 and GeoCAD (PC-based).

The main foreign system in Denmark is Intergraph. CV has some installations.

1.3 Finland

GIS investments in 1988 were $ 6 600 000 of which 50 % were Finnish systems. The dominating Finnish system is FINGIS which is developed in the Finnish National Board of Survey. The FINGIS GIS system is used for land use planning, map data inventory and production of conventional maps, and has applications for cadastre, utilities, road networks etc. FINGIS is running on VAX, and will be available on UNIX during 1989.

FINGIS has been exported to Sweden, Holland and a pilot project has been started in Canton, China.

The main foreign system in Finland is Intergraph. SysScan is also represented.

1.4 Norway

GIS investments in 1988 were $10 500 000 of which 86 % were Norwegian systems. The main Norwegian system is SysScan running on VAX, now also under conversion to IBM. SysScan is the most successful Nordic GIS system with a world-wide sales organization. Exports in 1988 were valued at $ 18 million which is approximately half of the estimated total Nordic export figures for GIS systems and services. Another Norwegian system is PUMATEC running on the leading Norwegian computer company Norsk Data. The system is exported to some countries.

The main foreign systems in Norway are ArcInfo (PC- and mini- versions) and Intergraph. Terrasoft has some installations mainly for applications in forestry.

1.5 Sweden

GIS investments in 1988 were $ 15 100 000 of which only 15 % were Swedish systems. In those figures we have not included the Teragon/Context image processing system which is the main Nordic manufacturer of image processing equipment for satellite data. Teragon/Context is dominating this market in the Nordic countries. The Main Swedish GIS system is AutoKa owned by the National Survey Department and Kordab from Kordab AB, both running on micro computers.

The main foreign systems in Sweden are Intergraph, Siemens and SysScan. ArcInfo and Terrasoft have a number of installations.

2 STRATEGY FOR IMPLEMENTATION OF GIS - A NORDIC APPROACH

The costs of operating and maintaining municipal engineering facilities in the Nordic countries is estimated at more than $ 15 000 000 000 annually. Geographical information is needed not only for operation and maintenance but also for planning, design and decision-making. These activities are being increasingly computerized.

Even small improvements to information processing can have far-reaching economic consequences, in view of the large sums of money already mentioned. A joint Nordic project - "NORDISK KVANTIF" - with the purpose of quantifying the community benefit of digital spatial information, was carried out in the period 1985-87. In this chapter some of the conclusions from the final report regarding costs and benefits as well as recommended strategy for implementation are summarized.

2.2 Costs and Benefits

Studies during the project showed that benefit-cost ratios achieved through GIS investments can easily bear comparison with the profitability requirements of private industry. At the same time, it was apparent that questions concerning the organization of the activities involved often present a greater task than purely technical issues. In order, therefore, to achieve the possible and demonstrated beneficial effects direction and control have to be exercised from the right level. If, for example, the aim is to obtain digital support for the supply and handling of positional information common to everybody who is actively involved in a particular field, this calls for a high

level of control. If, on the other hand, the aim is to obtain digital support for the production of maps within an administration or for a particular product, this will not call for such a high level of control. The diagram below shows that the benefit/cost ratio obtainable through GIS introduction is dependent on level of ambition.

FIGURE 1

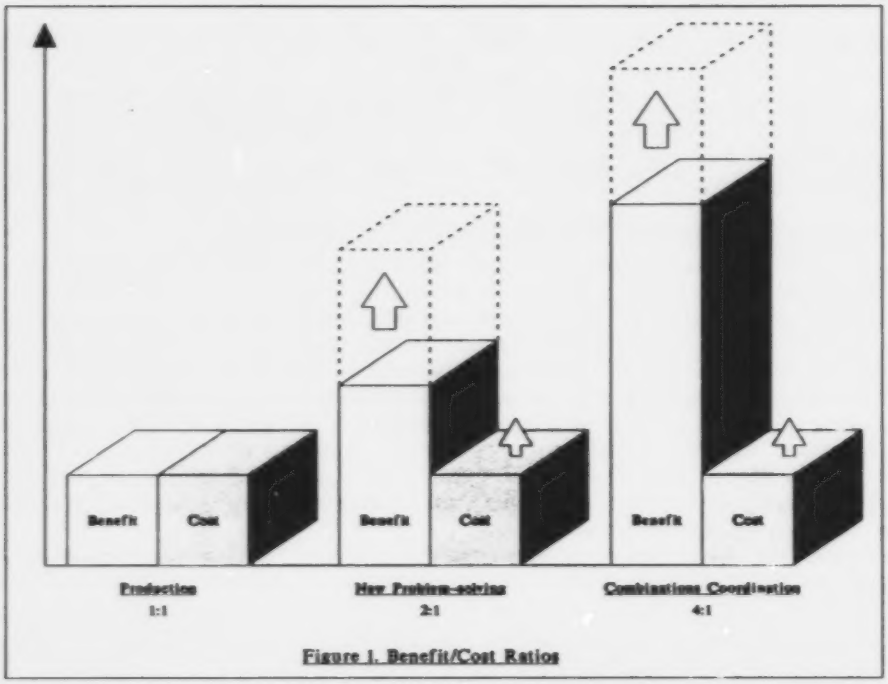


Figure 1. Benefit/Cost Ratios

If GIS is introduced as a production tool only, we found that in most cases benefit/cost ratios of about 1:1 were achieved. It will be possible to reduce the drafting staff to about the half, of operators. Even if the need for drafting staff was reduced we found in nearly all cases that the idle personnel was allocated to more useful and interesting tasks in the organization instead of being unemployed.

Higher beneficial effects have been achieved if GIS also has been used for internal planning and administration (the users of the information) in the actual organization. At the same time costs were somewhat higher as more equipment and training of more personnel is needed. Benefit/cost ratios of at least 2:1 should be achieved. If, moreover, the basic information can be used for new problem-solving in capital-intensive activities, the benefit/cost ratio can at best rise to 5-7:1.

The highest beneficial effect for the community is established in cases where full co-ordination has been achieved between different organizations using the same geographical information for planning, design and administration of for example public utilities. At least 4:1 should be possible to attend.

In Norway, the above statements are referred to as "the 1:2:4 rule" for benefits from GIS introduction. The Nordic countries have, through the political systems, a favorable background for achieving a high level of co-ordination, and subsequently high benefit, from GIS. Normally public utilities such as water, sewerage, electricity and telecommunication are administrated by the municipality or the government. In the USA for example, where most of the utilities are operated by private companies we found low levels of co-operation to be the normal case. Benefit/cost ratios here were normally around 2:1 in efficient cases. This is, however, sufficient to make GIS investments competitive to alternative investments in the utility companies.

The chart below illustrates a healthy, positive development of cost/benefit relations. A picture of this kind is only obtainable with a properly thought-out strategy. The project has shown that the likelihood of finding a proper strategy is distinctly increased when the introduction of GIS begins with cost/benefit analyses based on user studies.

FIGURE 2

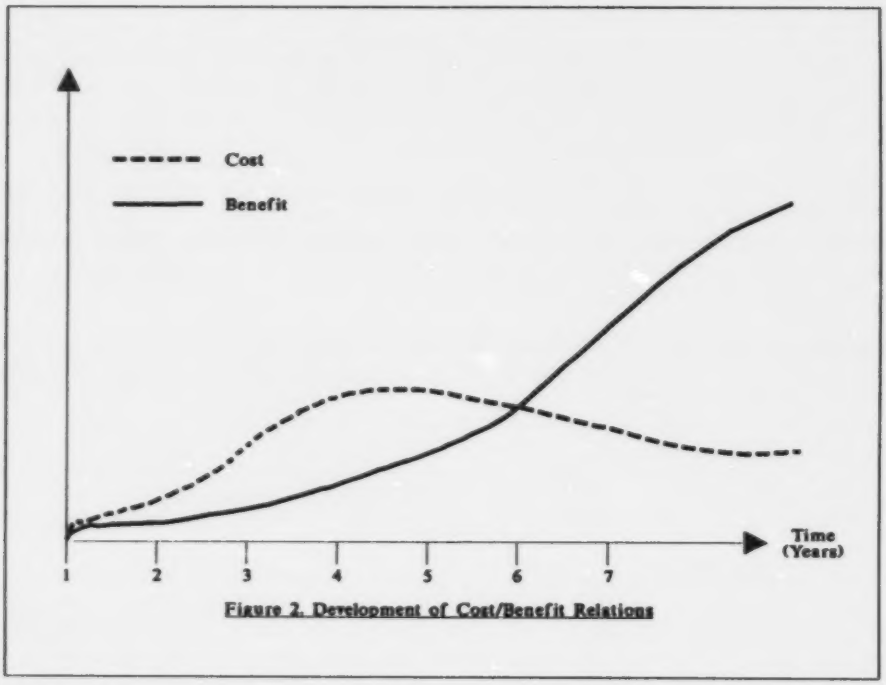


Figure 2. Development of Cost/Benefit Relations

2.3 Recommended strategy for implementation of GIS

We found no indications in the project to show that certain systems or software yield better profitability than others and could therefore be recommended. The level of success was varying from no benefit at all to benefit/cost ratios higher than 5:1. This was dependent on organization, co-operation and technical skill, and selection of the right strategy for implementation. Below are some key questions to be considered to achieve a best possible economic yield out of GIS investments:

1. Begin now or later?
2. Invest aggressively or within the normal budget?
3. Tailor-made or general systems?
4. Limited or comprehensive geographical coverage?
5. Build-up and maintenance of the database?
6. Changes of organization and routines?

The following recommendations are made in reply to these questions, with regard to the current developmental state of digital technology and in the light of our studies.

2.3.1 Starting Up

* Waiting means later results.

* Technology is no longer an expensive bottleneck.

* Don't obstruct the disseminating of information in the community!

Technical progress has now reached a stage where it no longer constitutes a bottleneck for traditional products and applications. Deferment of introduction means an additional time lag and augments the cost of future conversion. Remember too that technical progress is a continuous process whereby you will still be facing the same problems in the future.

In cases where work is devoted to selecting a suitable strategy, it has not been possible to establish in this project that greater benefits would have been achieved by postponing the start. Organizations thus awaiting events are also found to have a negative impact on the flow of information in society, the reason being that information in digital form cannot then be transmitted to other users in the community by whom it is needed, or to those who subsequently introduce digital processing.

Normally, an organization only takes this kind of technological step once in its lifetime. Dealing with such a situation can in itself be expensive, frustrating and time-consuming, and so it is normal to engage outside assistance in the selection of strategy.

2.3.2 Investment Intensity

* All experience shows that, once the objective has been decided on, a high rate of investment is needed in order to obtain a high level of benefit within a short time. (Equipment, personnel, data, organization.)

* Conversion of data should be done rapidly.

* The effect will not come until a complete database has been established for at least one theme/application.

* Several themes in one and the same field have a synergistic effect.

Practical experience from users interviewed in the project has shown that relatively intensive investments are needed. Above all, information should be converted with great care and within the shortest possible period, provided of course, that the needs and fields of activity to be concentrated on were specified before the decision was made. The reason for preferring a short conversion period is that no benefit will be obtained until a complete database exists for at least one theme. Additional themes of a single kind will enhance the benefit to reach individual users, due to synergistic effects. Tests of smaller systems are to be recommended during pilot study and pilot project, as a means of obtaining practical experience with the technology and its possibilities.

2.3.3 General or Tailor-made System - Cooperation

* Choose a general system from the beginning.

* A tailor-made system limits the possibility of development and reduces the beneficial effects of the database.

* Co-operation among agencies and organizations is low in the USA. This limits the benefit/cost ratio when adopting digital technique to 2:1.

* Canada and the Nordic area present a better climate for information interchange and co-ordination across organizational and administrative boundaries. This facilitates a benefit/cost ratio of 4:1.

The best idea is to bank on a distributive system from the very outset. Experience has shown that in the great majority of cases a general system confers most benefit on users. In the USA it is normal to introduce tailor-made systems for every organization. This limits the opportunities for information interchange between different organizations. The climate for co-operation between different organizations and companies is more favorable in the Nordic area and Canada. This means more opportunity for the joint build-up of information systems.

2.3.4 Field Coverage

* Introduce at least one theme in a complete administrative field.

* A mixture of analogue and digital information for the same theme, with parallel routines, should be avoided.

Field coverage will of course depend on the activities which are to benefit from the information. Activities are often divided into different administrative or functional fields. It is always an advantage if a complete field of this kind can work with the aid of a new technique introduced. The use of parallel routines within such a field leads to unnecessary duplication, problems of interpretation, etc. Individual projects within a field of activity can benefit from digital support. The benefit in other fields or to subsequent activities, however, is difficult to achieve with the surrounding information being processed by traditional methods.

2.3.5 Build-up and Maintenance of the Database

* The content of the database is selected, right from the start, with reference to the needs of identified users.

* Distinguish between common and user-specific information

* The base(s) must be structured in such a way as to facilitate flexible use of data and the updating and expansion of content.

* Once the base has been installed, the users will find a host of new applications.

* User-specific information should be stored and maintained by the individual user.

* Try to make provision for future technical developments.

Without any information users, it is hard to arrive at a practical scheme of maintenance. Make a policy, therefore, of entering a content selected with reference to identified user needs. Information entered in case somebody should happen to need it often causes problems. Choose a flexible, expandable database structure instead. This will facilitate additions when needs are identified. Segregate common and user-specific information. For municipal engineering activities, for example, the geographical localization of facilities and a "base map" constitute important common information. Particulars about facilities and statistics relating to them, on the other hand, are for the most part valueless except to the administration or enterprise concerned.

2.3.6 Organization Conditions

* Organization problems present more of a challenge than technical ones

* The introduction of GIS leads to changes in existing routines for information exchanges between and within administrative authorities (e.g. the establishment of networks).

* Organization changes within the individual administration are also necessary in consequence of revised working routines.

* Normally speaking, every organizational change is opposed by at least 25% of the personnel.

* Project-orientate the introductory phases when introducing GIS.

* Permanent organizational changes can only be introduced after introductory experimental operation.

All organizations switching to GIS must devote a great deal of attention to organizational questions of different kinds. These questions are often more complicated than technical questions and at the same time crucial to the degree of success achieved. It is essential for permanent working units in the organization to feel genuinely responsible for creating and maintaining the entire organization/function with a complete overview and overriding responsibility. It is normal for the introduction of GIS to lead to changes of organization and routines, both within and between different organizations and administrative units.

The figure below shows what optimum introduction can look like, given the right choice of strategy. This figure also illustrates the benefits and costs figures. Benefit will be higher than costs first when the database for the actual area is converted. More themes in a common data base creates synergy effect and increases the benefit.

FIGURE 3

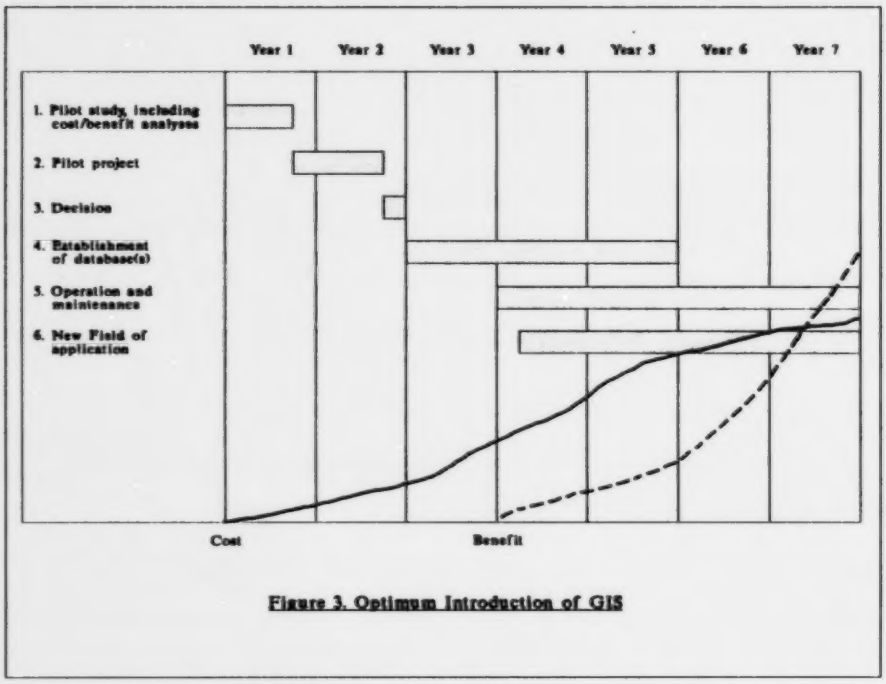


Figure 3. Optimum introduction of GIS

3 APPLICATION TO GIS TO FORESTRY AND NATURAL RESOURCES IN NORWAY

A growing number of firms and organizations in the Nordic countries have during the last years taken into use GIS in mapping and management of forestry and natural resources. Below is a description of the most well-known installations in Norway. It is seen that Terrasoft and ArcInfo so far dominate the market for GIS applications to forestry and natural resources in Norway.

3.1 Terrasoft Installations

Fotokart A/S, Kongsberg, Norway.
Tel: 47-3-732350 (Bakken)

Fotokart delivers stand maps from photo surveys to forest owners associations. Up to now the products have mainly been hand-drawn overlays of stands, copied onto economic maps, with maturity class and site class added for the individual stands. In addition they deliver lists of areas, summed for each property or part of property, plus other stand information from the photo-survey. This information is stored on dBase-files that can be directly connected to the digital map in the GIS-part of Terrasoft.

The use of GIS has been mainly experimental up to now. The most likely products are thematic maps for various combinations of maturity class and site class, plus reports/statistics about area composition of properties according to various characteristics from the stand survey. GIS is also used to extract, for example, information about stands in a 100-metre belt along forest roads. Use of raster plotter for map presentation is presently being evaluated.

Norwegian Institute of Land Inventory (NIJOS), As, Norway.
Tel: 47-9-948850 (Hjeltnes/Angeloff)

NIJOS uses both the digitizing, plotting and analyses parts of Terrasoft. One of the digitizing systems operates a PC-based analytical stereo instrument, AP 190 (Carto Instruments).

Area data

Terrasoft is used both for vegetation mapping and soils mapping. After a digital manuscript for a mapping theme (cover) is established, various subthemes are derived from the polygon label point signatures using the data bases programming system DBXL (for example, map of grazing value or productivity derived from vegetation maps). This theme can then be drawn on a topographic base map in an appropriate scale with a plotter that gives visually contiguous colours.

NIJOS has its own area summation program that gives area data for desired area classes.

Point data

A data base of characteristics is coupled to the point net. This is expanded upon using the DBXL-program to include for example climatic parameters and information on plant or tree species. Mapping themes that are combinations of the information contained for each point are defined in a separate program. These themes are presented as various symbols from the symbol register in Terrasoft.

Line data

Plans are being made for "traffic load maps" for natural and other areas. Data on the type and intensity of traffic will be combined with production data and vulnerability to damage, and the new map themes emerging from this combination will be plotted out.

(This type of analysis result, based on GIS-technique, is considered an important information product in our society, where all political parties have a common goal that the general public should have insight into and contribute to planning and management of natural resources and the environment).

The State Forests and Lands Administration, Oslo, Norway
Tel : 47-2-417320 (Berg)

The State Forests and Lands Administration is responsible for mapping and survey of state-owned forest lands. Boundaries for forest stands are digitized manually, with subsequent calculation of areas and plotting of transparencies. Maps containing stand boundaries are used together with register data as a basis for planning. 27 000 hectares have been mapped by Terrasoft. 69 300 hectares have been mapped by the Norwegian system MAPDAT-Skog. All the material is now being converted to Terrasoft.

Application of GIS has until now been limited to map production. Map production and area calculation using GIS is at present not less expensive than manual methods. It is expected that GIS will be more advantageous with repeated surveying, and that GIS techniques will gradually find a place as a tool for rolling local planning. The State Forests and Lands Administration is expected to become a significant user of GIS.

Plans also exist for the use of GIS in connection with cultivation plans, development of tourism, and other activities within areas managed by the State Forests and Lands Administration.

Norwegian Mapping Authority, Resource Division, Honefoss, Norway
Tel: 47-67-24100 (Gilhus)

The Norwegian Mapping Authority has Terrasoft in their training lab, but it is not used in the normal production.

Geological Survey of Norway, Trondheim, Norway
Tel: 47-921611 (Nilsen, Rindstad)

Mineralogy, quaternary geology, hydro geology, geochemical and other geological mapping. They have used Terrasoft until now for terrain modeling, geochemical mapping and for construction of data bases for characteristics. ArcInfo and other programs are under evaluation. No decision has been made as to which system will be used most.

3.2 ArcInfo Installations

ArcInfo, especially the PC version, spread rapidly in Norway last year, and Norway has, as far as we know, the most users of this program in the Nordic Countries. The minicomputer version is also installed in several places.

Centre for GIS and Remote Sensing, Arendal, Norway
Tel: 47-41-38870 (Bernhardsen)

One of the most interesting installations is perhaps at the Centre for GIS and Remote Sensing, where preparations are being made to couple ArcInfo (on VAX) to the swedish image-processing system Teragon. The Centre is working as consultants in GIS and remote sensing in Norway and abroad, and carries out image processing, satellite mapping, satellite/GIS applications and establishment of geographic and environmental databases. Vegetation mapping from satellite data is a specialty. The Centre also undertakes training and education and institutional building in less developed countries.

In the fields of forestry and natural resources the Centre is at present testing SPOT HRV and Landsat-5 TM-data in forest resource mapping in two townships in Aust-Agder County. Ground truth consists of forest inventory in forest productive areas, and plant sociological mapping above the tree line. The study aims at clarifying the possibilities for use of satellite data for overview mapping and stratification, for example as a basis for structuring mapping at more detailed levels. Whether existing, traditional methods for detailed mapping can be adapted to make cost-effective use of satellite data, is also considered.

Satellite data and digitalized, infrared-sensitive colour photographs are also tested for practical application in identification of forest decline. Special emphasis is given to tree vitality in parks and adjacent areas of the industrial town Porsgrunn, Telemark County. All satellite images are precision corrected, and can be combined with topographic or thematic maps at given scales, for analyses and for the documentation of findings.

Mapping of environmental data has started extensively as a part of a national project with 80 Norwegian municipalities involved in pilot projects for environmental management.

This year mapping of national parks will be started up.

The Centre is at present working with vegetation mapping fro a major fuel wood project in Malawi funded by NORAD (Norwegian Agency for Development Aid).

The Centre might become a Norwegian national node to UNEPs Global Resource Information Database (GRID), headquartered in Nairobi, Kenya. Establishment of a GRID node in Norway is expected to be one of the recommendations in a parliamentary report on Norwegian follow up to the World Commission on Environment and Development, headed by the Norwegian Prime Minister Gro Harlem Brundtland.

Institute for Environmental Analyses, Bo, Norway
Tel: 47-3-950499 (Hesjedal)

The Institute is installing ArcInfo and ERDAS for research and development, teaching and small projects in Norway and less developed countries. Applications include all kinds of environmental data. The Institute is co-owner of the Centre for GIS and Remote Sensing in Arendal, and the installation can be related to internationalization of activities there and projects for the Ministry of Development Cooperation, Norway.

Norwegian Institute of Land Inventory (NIJOS)

NIJOS is starting up several work stations with ArcInfo for projects as discussed under TerraSoft.

There is good reason to suppose that ArcInfo and ArcInfo/digital image processing will come into relatively wide use in Norway in the coming years, not least in connection with the analysis of natural resources and environmental data. In addition to the installation at the Institute for Environmental Analysis, ERDAS/ArcInfo is under planning or trial at several other institutes that work with environmental data, including the Norwegian Mapping Authority, Resource Division and the Directorate for Nature Management in Trondheim. A combination of ArcInfo and I2S is reportedly under way at Tromso University. Increasing interest in these GIS-systems has also been shown in the institutions working with projects in Development Cooperation.

One further condition for a true "breakthrough" in user environments is menu-steering. ArcInfo is still considered complex for new users, with a multitude of commands and possibilities in various "boxes". It will take some time to structure production methods that can easily be adopted by personnel without special training.

3.3 SYSSCAN, PUMATEC, MAPDAT-skog and Other Installations

These are Norwegian systems, the first two are relatively expensive as complete systems. There are few users in forest and resource mapping. MAPDAT-skog has (and has had) users in the forestry sector. The State Forests and Lands Administration has mapped 69 300 hectares using MAPDAT-skog. The program seems to have problems with getting upgraded at the same rate as ArcInfo and Terrasoft, for example.

4 REFERENCES

NORDISK KVANTIF. March 1986. **Samfunnsnytten av digital stedfestet informasjon, delrapport 1 : Status i Norden.**

NORDISK KVANTIF. March 1987. **Community Benefit of Digital Spatial Information, Report 3: Digital map data bases, Economics and user experiences in North America.**

NORDISK KVANTIF. October 1987. **Community Benefit of Digital Spatial Information,: Final report, Conclusions and recommendations.**

Anderson U. and Rystedt Bengt. February 1988. **Scandinavian Activities in the LIS/GIS Area, Photogrammetric Engineering and Remote Sensing, Vol. 54, No. 2.**

Persson Clas-Goran. October 1988. **Research and Development Within the Field of Geographic Information Systems in Sweden.**

GIS - A TOOL IN FOREST PEST MANAGEMENT

G.A. Van Sickle

Head, Forest Insect and Disease Survey
Forestry Canada
Pacific Forestry Centre
506 W. Burnside Rd.
Victoria, B.C. V8Z 1M5

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

The Forest Insect and Disease Survey of Forestry Canada annually monitors forest pest conditions across Canada. About 1/2 million insect and disease records on a wide range of forest plants exist for British Columbia, and major infestations continue to be mapped annually. Through GIS capabilities developed at the Pacific Forestry Centre, regional and provincial pest summaries are prepared, multi-year infestations analyzed, and comparisons of pest distributions made with biogeoclimatic zones, inventory, or climatic and moisture data. Results help in risk rating stands for potential pest problems, display infestations for control planning, and allow analysis of possible relationship among pests, and between pests and other factors.

INTRODUCTION

Tree mortality and growth loss caused by forest pests in the Pacific Region each year exceed 25 million m^3, which is a volume equivalent to about one-third of that harvested annually. To the extent that major losses to bark beetles, defoliators, dwarf mistletoes and root rots can be salvaged or reduced, the impact of projected wood supply shortages can be alleviated. Additionally, there are losses not easily measured by volume such as constraints on the use of desirable species; constraints on seedling movement or trade exports because of international and provincial quarantines; losses in young stands, in aesthetics, in recreational values or increased fire hazards. Also, significant and increasing investments in silviculture can be eroded if pests necessitate replanting or cause understocking of thinned stands before they reach merchantability.

The Forest Insect and Disease Survey (FIDS) of Forestry Canada each year conducts an overview of pest conditions in the forests of Canada which is useful in support of: forest management decisions; regional, national and international plant quarantines and regulations; and in forest research and development programs. The surveys are accomplished in part by random and permanent sampling station collections and observations, pheromone trapping, stand cruises, evaluation of parasitism, egg counts to forecast future populations and damage, aerial detection and delineation mapping, photography, and extensive liaison with industrial and provincial forests or parks staff. The great diversity of topography, climate, vegetation and pests over the 51 million ha of productive forest in B.C. and 8 million ha in the Yukon Territory creates a complex mosaic of information difficult to interpret and manage.

The Forest Insect and Disease Survey has annually monitored forest pest conditions and maintained records of identifications and collections of forest insects and diseases since 1936. In the Pacific Region, additional observations and collections were made even pre-1900. Almost 40% of the national data base of 1.3 million pest specific records are from the Pacific Region. Included in this regional database maintained at Pacific Forestry Centre (PFC) are 171,000 disease and 295,000 insect and parasite records with associated host and location information. About 6 000 new records are added annually. This paper describes developments with a geographic information system (GIS) since 1984 to more accurately, quickly and thoroughly present, analyze and interpret annual and historical records.

INPUTS AND EQUIPMENT

Aerial surveys for detection and mapping of forest pests have been quite regular since 1960 and were conducted for selective problems since the late '40's. Earlier cartographic records of infestations were largely limited to mapping from vantage points and date back to the '20's. For provincial and national overviews, aerial sketchmapping is still the most time and cost-effective procedure for conducting a detection and initial survey over vast areas on a yearly basis. Currently, sketchmapping for a first stage overview is mostly on 1:100 000 scale maps, occasionally at larger scales and, if necessary because of map availability throughout the region, at smaller scales up to 1:250 000. Consistency is increased by using the same few experienced observers. Sketchmapping can often be completed under less rigorous weather conditions than photography, reports and summaries are more readily available, and costs are only about 10 cents/km^2. Areas justifying more detailed helicopter reconnaissance or photography can then be identified and efforts better focused. Attributes for each sketched polygon normally include tree species damaged, severity, year, and pest. Those pests most commonly distinguishable from fixed-wing aircraft include the major bark beetles; defoliators such as budworm, Douglas-fir tussock moth, and tent caterpillars; and porcupine, blowdown and storm damage.

Ground-based observations and collections have included additional information on geographic location based on a 10 km UTM grid, elevation, stand attributes, host tree, sampling method, pest species identification, collector, date, etc. Since 1967 this has been a standardized 80 column entry and earlier records were converted from punch cards. Both the ground and aerial records can be usefully presented, analyzed and summarized with a GIS.

The large volume of the national database can be accessed and manipulated through FIDS INFOBASE, a relational database management system using INGRES developed by the FIDS technology development project (Power 1986). It is currently operating on a Digital Equipment Corporation VAX 11/750 at the Petawawa National Forestry Institute in Ontario with decentralized on-line capability to input, update and retrieve regional data. The required data can be selected and summarized within INFOBASE or by standard SAS routines, then if geographic presentation is necessary, transferred to a GIS.

Development of GIS capabilities has been underway at Pacific Forestry Centre (PFC) since 1984. Through a development agreement with Northwest Digital Research Ltd. of Vancouver, hardware was supplied and the necessary software links developed to make their program series "OVERLAY" suitable for regional FIDS mapping and analysis. The system was purchased in 1986 with cooperation and development continuing. OVERLAY is a spatial analysis and spatial database module which inputs in vector, raster, text and polygon form. Spatial data is managed using an unique proprietary data structure called associative maps. Attributes, resolution and number of layers are limited only by hardware capacity. It is currently running on a Hewlett-Packard work station linked to a large E-size plotter and digitizer, a 9-track tape drive, high resolution monitor, printer and a 400 M byte disc drive. Easy selections can be made using the mouse or keyboard of 7 levels of display or plot resolution, normal or polyconic projections, 15 colors, 8 fill patterns, variable paper or map size, variable or customized map windows, and overlay functions of union, subtraction, etc.

Presently the system contains data for more than 700 insect or disease maps (with additional historical maps being digitized as time permits); biogeoclimatic (ecological) zone maps for B.C. at 1:2 million; selected geographic data to create outline maps of boundaries, lakes, rivers, major towns and B.C. Forest Service forest regions; a partial national level forest inventory; and some detailed forest cover information, growing degree days and climatic moisture deficits.

OUTPUTS

Annual infestation maps and summaries

Upon completion of the aerial surveys each year in August or September, the field technicians return to PFC and enter into the GIS the current infestations by digitizing the polygons and assigning attributes of pest, severity, year, forest region and map reference. From these data, searches or compilations, of any combination of desired attributes can be made. A map of the previous year's infestations is generally used during flights to improve the accuracy of locating continuing infestations, to more clearly identify changes and to ensure that major infestations are reflown. Also, during digitizing the current and previous year's infestations can be viewed on the screen and any differences are corrected or accepted by the technician before entry into the database. With the field technicians responsible for input of their own data, errors of missing labels, placement, etc. can be detected and corrected.

Maps are then computer-produced at various scales and distributed to cooperating provincial forest service and forest industry staff, and are available to parks and others. By combining 20 to more than 100 such maps, regional and provincial maps are available for review and planning meetings and reports (Figure 1). Rapid edge matching of data from virtually any number of maps or scale, and relative ease of the digitizing procedure are advantages of the developed software. Using report generators, area and polygon tallies can be derived for selected areas, map sheets, regions or the Province (Tables 1 and 2).

TABLE 1

AREA (HA) OF SELECTED INSECT INFESTATIONS IN BRITISH COLUMBIA IN 1988 BY FOREST REGION.

Pest	Cariboo	Kamloops	Nelson	Prince George	Prince Rupert	Vancouver	Total
Mountain pine beetle	1290	17642	26180	3972	12974	841	62898
Western budworm	8047	344710	3275	0	0	3640	359671
2-year cycle budworm	40215	44452	0	17519	0	0	102185
Eastern budworm	0	0	0	35889	0	0	35889
Blackheaded budworm	0	877	0	0	58669	4829	64375
Forest tent caterpillar	462	0	1536	48317	1557	0	51872

TABLE 2

AREA (HA), SEVERITY AND NUMBER OF AERIALLY MAPPED POLYGONS OF FOREST PESTS FOR A SELECTED (1:100000) MAP SHEET IN 1988.

Mapsheet	Pest	Severity	Area (ha)	Number
Elko - 1988				
	Douglas-fir beetle	severe	1	2
	Forest tent caterpillar	severe	100	3
	Larch sawfly	moderate	21	2
	Mountain pine beetle	light	4129	306
		moderate	294	24
		severe	192	635

Multi-year overlays

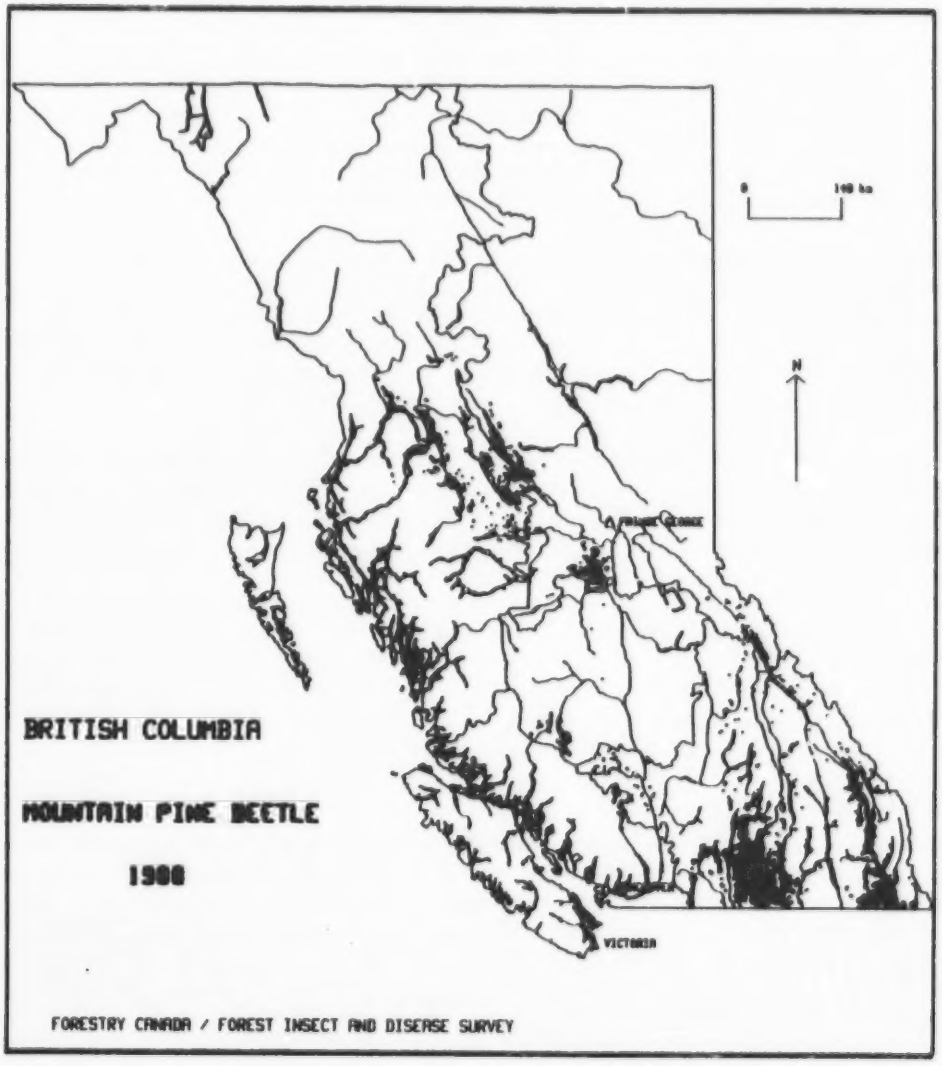
The ability to create and analyze multiple overlays is a most useful function. In 1987, Douglas-fir over more than 834 000 ha were defoliated by the western spruce budworm which was the largest infestation by this insect recorded in British Columbia. This insect feeds preferentially on current year foliage, hence damage is greatest after several consecutive years of feeding. In order to identify areas of greatest damage and better determine the magnitude of the problem, overlays of the yearly defoliation maps for 1983 to 1988 were created and analyzed. Almost half of the total area had been defoliated for one of the six years, 36% for two consecutive years, and 15% for three or four years. Only 1% had been defoliated five or more years. Areas could be identified for salvage, treatment consideration, or deferred action.

In a similar manner, long-term records of occurrence and severity for pests of concern can be summarized and visually displayed for use in planning. To the extent that history is a good teacher, the forest manager could consider planting non-host trees in areas of highest infestation frequencies, or at least be forewarned to expect 0, 1, or more infestations during the next rotation. Mapping the spread of introduced forest insects such as larch casebearer over time is similarly possible and useful.

Analysis of relationships

GIS's can also be wonderful integrators of efforts in many areas. Specialists in many fields (entomology, pathology, soils, hydrology, fire, climate, mensuration, recreation, wildlife, remote sensing, modelling, etc.) can enter and use data of unique interest and the opportunities and benefits of interaction greatly exceed the sum of the parts. In the past, possible relationships between or among insect and disease distribution patterns, biogeoclimatic zones, climatic variables, forest types, slope or aspect, etc., were difficult to evaluate or quantify. GIS capabilities greatly reduce the drudgery and make possible "let's look at..." scenarios.

FIGURE 1
REGIONAL SUMMARY MAP OF MOUNTAIN PINE BEETLE IN 1988
A COMPUTER AMALGAMATION OF 72 MAP SHEETS, MOSTLY 1:100 000 SCALE
INVOLVING 8,558 POLYGONS WITH A CUMULATIVE AREA OF 62 898 HA



Douglas-fir tussock moth periodically causes severe defoliation, growth loss and mortality of young and mature Douglas-fir. Defoliation has been mapped by the Forest Insect and Disease Survey during eight outbreak periods since 1916. Each period of defoliation by Douglas-fir tussock moth usually lasts one to four years before natural factors, usually a virus, reduce the larval populations. These were overlaid to determine correspondence of the insect with forest habitat and climatic maps in order to identify the most susceptible ecozones and key climatic conditions. More than 600 overlays, intersections, unions or subtractions of map polygons were completed which would have been impossible without a GIS.

Of the 12 ecological zones considered, the majority of the infestations occurred within PPBGd and IDFc and a, and within these where temperatures were moderate (1,500 to 1,900 cumulative degree days/growing season), and where moisture deficits were extreme (-300 to -500 mm/growing season) (Shepherd, Van Sickle and Clarke, In press). Identification of the most susceptible areas and stand types focuses and improves monitoring techniques, provides a basis for risk assessment and identifies the probable need and frequency for direct control of infestations in future rotations. Information on the environmental requirements and limitations for outbreaks can improve predictions of where and when future outbreaks will occur, and is basic to estimating damage which may be expected with climatic shifts because of atmospheric pollution or global warming effects. An additional useful observation was revealed during the GIS analysis. Even though multiple outbreaks had been recorded and referenced to the same place names, exact geographic overlaps were not common. Of the total area defoliated in the 8 outbreaks, 90% had been defoliated once, 8% defoliated twice, and only 2% defoliated three times.

The GIS is also being used in cooperation with a contractor to compare the historical areas of western budworm defoliation and various stand harvesting or management procedures. From aerial sketch mapped records of widely scattered, previously defoliated stands totalling more than 800 000 ha and almost 500 stand harvesting records, 95 locations were selected for further analysis and of these, only 15 of these had sufficient historical data. In this case, GIS analysis quickly identified the few stands which satisfied the sampling requirements and focused the subsequent fieldwork.

Pest distribution maps developed from a computer search of many years records and plotted using the GIS have also been useful in plant quarantines (e.g. the introduced balsam woolly adelgid), or in managing the large insect and disease collection to quickly determine which new collections represent significant extensions of known distributions. Some pest outbreaks, such as black army cutworm are in part initiated by wild or prescribed fires, and distribution maps assist forest managers in identifying areas most frequently affected, and conversely those not affected, in order to modify silvicultural practices when appropriate.

By overlaying and combining pest distributions, severity and duration records with national level forest inventories (volume summaries by species for map sheet sized cells) and applying mortality and growth loss factors, pest-caused volume losses can be estimated. This is in progress with preparation of a regional contribution to a national reporting of losses to major forest insects and diseases during the last six years. The previous, rather laborious, estimate with many assumptions found more than 107 million m^3 were lost each year to pests from 1977 to 1981 (Sterner and Davidson 1982). With input, expectedly on machine-readable tape, of the geographic boundaries of parks, forest regions and districts, timber supply areas, electoral districts, etc., it should also be possible to partition the losses and pest distributions according to major land ownership types. Cooperation with the B.C. Forest Service for data sharing has been excellent with only the development of the software linkages between the different mapping system taking some time and effort.

CONCLUSIONS

A large national and regional historical database on the identification, hosts, distributions, frequency and cycles of many forest insects and diseases, has been created over several decades, but only recently has the computer capability of relational database management and geographic information systems enabled fuller analysis. To guide and assist forest protection research and management, the database can be interrogated interactively or in batch mode, a wide range of maps can be stored and produced, and maps can be overlaid, analyzed and summarized in association with pest distribution and history, forest inventory, biogeoclimatic vegetation zones, administrative boundaries or climatic and other records. Results help in risk-rating for potential pest problems,

support quarantine decisions and regulations, display infestations for control planning, and allow analysis of comparisons and relationships among pests and between pests and other factors -- and we've really just started to tap the power and integrating capabilities of the GIS!

REFERENCES

Power, J.M. 1986. **INFOBASE: The Forest Insect and Disease Survey Information System.** Canadian Forestry Service. Info. Rept. PI-X-65.

Shepherd, R.F., G.A. Van Sickle and D.H.L. Clarke. In press. **Spatial Relationships of Douglas-fir Tussock Moth Defoliation Within Habitat and Climatic Zones.** IN:Wallner, W.E. Comparison of features of new and old world tussock moths (Lymantriidae). Proceedings Symp. 1988. USFS, Hamden, Conn.

Sterner, T.E. and A.G. Davidson (edit). 1982. **Forest Insect and Disease Conditions in Canada, 1981.** Canadian Forestry Service, Ottawa.

DEVELOPING A NEW GIS - EVOLUTION OR REVOLUTION?

Richard R. Wakeley

Manager, Inventory and Systems
Weyerhaeuser Company
Tacoma, Washington

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Survival of any information system in changing management culture demands flexibility of both people and programs, particularly in the private sector. Response time to changing objectives is the key to success of any system including a GIS. Weyerhaeuser is in the process of building a new system, as we have been for the past 22 years, by evolution - not revolution.

JUSTIFICATION FOR GIS/MIS

David Wills

Director
Sierra Systems Consultants Inc.
Vancouver, British Columbia

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Completing some sort of strategic plan and cost benefit analysis have historically preceded most GIS projects. For some the justification emphasis is on financial payback. For others the justification may be in improving information handling, complying with government regulatory requirements or providing better planning. This paper takes a look at the technical issues and costs involved in developing a strategic plan and cost-benefit analysis. It discusses key steps required for a successful GIS cost-benefit analysis.

"PHOTOGRAMMETRY AS A DATA SOURCE FOR GIS"

S.E. (Al) Daykin

General Manager
Digital Mapping Group Ltd.
Burnaby,
British Columbia

GIS'89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

Creating and updating digital maps using photogrammetric techniques is a cost effective method of acquiring digital spatial data for use in geographic information systems. This paper deals with some of the technical and managerial considerations in the acquisition, training and implementation of a digital photogrammetric data capture system, some of the problems associated with acquiring and supplying spatial data to GIS users, and the related benefits of photogrammetric techniques.

In this age of satellite imagery, video cameras, and global positioning satellites it is often easy to overlook the many advantages and uses of aerial photography and the science of photogrammetry as sources of spatial information. Let me suggest some of the many reasons why aerial photos will continue to be an important primary source of spatial data for a long time to come.

From a historical perspective there is no substitute for aerial photography, and any project which monitors or reviews changes over time must rely on this medium. An example of this would be a cumulative environmental impact study to assess the incremental effect of an action when added to past, present and foreseeable future actions. Obviously satellite imagery and other remote sensing data are still relatively new to be of much historical significance, at least at this point in time.

In addition, despite the perceived capabilities of newer satellites, some not yet launched, aerial photography is still the standard for almost all topographic mapping in the world today. Satellite imagery may enable preliminary maps to be generated for areas of the world where no topographic data previously existed, but this imagery cannot provide the wealth of information available from aerial photography, nor the accuracy achievable by photogrammetric methods.

It is well to keep in mind that, although remote sensing data can be an important data source for a GIS, it cannot yet be considered a primary source. The accuracy, precision, and degree of detail required for most mapping projects, as well as for many GIS applications, dictates the use of aerial photos.

Having said that however, satellite imagery is being extensively used to record significant changes in the terrain -- recording cut-over blocks for forestry for example -- as well as for updating 1:250,000 scale national topographic series map sheets. Digital image processing systems now include most, if not all, of the functions of a GIS. These remote sensing analysis systems which include spatial data handling functions provide a powerful means for increasing the utility of remote sensing data.

One final advantage of aerial photography which must be considered concerns the ease and simplicity of use compared to other remotely sensed data. The aerial photograph might in fact be considered an introduction to remote sensing as a source of spatial data.

Conventional or analogue mapping on stereoplotters has been carried out in Canada for perhaps 50 years in both the public and private sectors. Although there have been significant technological advances in aerial cameras with virtually distortion free lenses, in stable based high resolution aerial films, and in the sophistication and improved capabilities of stereoplotters, mapping operations and management procedures have remained virtually unchanged over this period.

A recent advertisement by a prominent supplier suggests that "the last few years have seen a change in photogrammetry from graphic products to digital, brought about by the ubiquitous computer". How true. In fact the trend to digital mapping began in Canada during the late 1970's, about the same time that GIS began to emerge a decade ago.

For several years, however, most of this new digital mapping technology was directed towards automating the cartographic drafting process without much thought to its potential use as a digital topographic data base. In 1983 the Canadian Council on Surveying and Mapping, a joint Federal and Provincial body, produced a National Standard for the Exchange of Digital Topographic Data. These two volumes include standards and codes for classification of features, and standards for data exchange formats.

During the early 1980's hardware and software evolved rapidly and users began to demand more structured data. We are presently at the point where the shift from conventional to digital mapping is now almost complete in Canada, and the picture has changed dramatically.

- The Federal 1:50,000 scale mapping program is now almost fully digital. The existing 1:250,000 map series is also being scanned and converted to digital files.

- Almost all Provincial Governments are planning or have initiated digital base mapping programs, and most have at least one GIS-related inventory program now underway.

- Most major Canadian cities undertaking new mapping programs are opting for digital data as part of an integrated mapping system.

- Many larger engineering consultants are now ordering mapping in digital form to enable further processing and modelling on their own CAD systems.

This transition to digital technology has been a traumatic experience for aerial survey companies across Canada -- an industry long considered to be fully 'mature'. Costly hardware and software had to be purchased, new specialists hired, and an extensive period of retraining of existing staff was required.

At the same time both producers and users alike have been faced with rapidly-evolving product specifications, user requirements and system capabilities. In addition the learning process associated with this digital transition proved to take longer and was much more costly than many anticipated, causing some of the major Canadian mapping companies to restructure due to heavy financial losses, and several companies across Canada have in fact failed over the past three or four years.

The data capture process involved in digital mapping is far more complex than the production of analogue mapping. In many instances it is not an easy task for photogrammetric technicians to make the mental transition from producing a cartographic product, to one of producing topographic information as a series of points, lines and polygons or area features, all in machine readable formats. We must now specify three things to the computer:

- where each feature is in three dimensional geographic space,

- what each feature is by means of a feature code, and

- what each feature's spatial relationship is to other features in the map file.

Here in British Columbia only one or two companies had any previous digital mapping experience until the advent of the Provinces's TRIM program in 1986. The specifications for this project were developed to meet the current demands of users, and to deliver a digital topographic data base whose format is generic enough to meet the capabilities of most if not all GIS systems presently available.

To facilitate analysis, the data must be somewhat topologically structured which dictates certain rules during the data capture process.

- All polygonal or aereal features are captured using a right hand rule, and are explicitly closed by duplicating other features where necessary.

- A continuity rule ensures that all hydrographic features are unbroken and continuous, and these features are captured in a downstream direction.

- Connectivity and networking is assured by having all like and unlike features which intersect or close on themselves do at numerically and mathematically exact coordinate junction points or nodes -- in most cases an exact three dimensional node.

The difficult topography of this Province dictates that all features must be captured three-dimensionally. Instead of producing contours manually, a digital elevation model is generated during data capture which provides more information in terms of terrain modelling, as well as providing the capability of producing varying contour intervals using the computer. This same digital elevation data can be used to geometrically correct satellite imagery and will no doubt provide the means of updating the TRIM topographic data base as the resolution of satellite imagery improves in the future.

Although the interpretive process of recognizing and capturing features is much the same for digital mapping as for analogue, the digital procedures are much more complex and demanding, in order to ensure the integrity of the digital topographic data files.

The shift in major market emphasis from conventional to digital mapping is now almost complete in Canada, and virtually all companies are seriously involved with digital mapping, and to some degree with geographic information systems. Mapping companies are also providing data conversion services, including manual digitizing of existing graphic products, as well as the input of related statistical or attribute data. Some companies also provide consulting services, assisting users in the implementation of GIS, researching data sources, or in preparing specifications for data acquisition.

Clearly GIS technology is a tool that has the potential to assist in the performance of specified activities more effectively, efficiently and accurately by automating the heretofore manual process of gathering and analyzing data as an input to decision making. Front-end costs associated with implementing a GIS are rather high however, and one should not expect a payback early in the life of such a program. An analysis of the costs and benefits of incorporating GIS technology may be appropriate before making such a commitment.

In addition to the obvious capital costs of hardware and software, and of system maintenance, there are the not so obvious but significant costs related to data input and personnel training which are often more than a user anticipates. Benefits are more difficult to quantify and include information efficiency, analysis capability, cost avoidance due to error avoidance, and ultimately cost savings compared to manual methods. But one should not expect an early return on investment -- like digital mapping or playing poker - the learning process associated with implementing GIS can be costly.

Finally, there is a wealth of existing spatial and textual data presently available in the public sector which may answer some GIS needs. Care should be taken however to check the suitability of the data in terms of age, format, method of collection, and completeness as well as accuracy. When in doubt one can always revert to the tried and true digital photogrammetric techniques which will continue to provide the structured data required for GIS for years to come.

REFERENCES

Congalton, Russell. 1989-Mosaic, January/February issue, **Professional Surveyor.**

Colman, David J. and John D. Mclaughlin. 1987 . **The Shift to Digital Mapping: Points of Impact on Management.**

Parker, H. Dennis. 1988. **The Unique Qualities of a Geographic Information System: A Commentary.** Volume 54, No. 11, Photogrammetric Engineering and Remote Sensing.

TEXT OF AFTER-LUNCH SPEEECH

Chuck Lankester

Principal Technical Advisor
United Nations Development Programme
New York

GIS'89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

Note

The following text was transcribed from a tape of Mr Lankester's speech, and has not been subsequently edited for content correctness or style.

Ladies and Gentlemen, my short speech is as follows:

- I want to tell you that the environmental situation out there stinks;
- that we have to correct it or we will all go down the tubes together;
- and that to do so is going to require a great deal of skill, imagination and a lot of money.

And thank you.

My long speech is a bit trickier. I have to develop those three points, introduce at least two more and show a few slides. And since you have already been gracious enough to reimburse my round trip ticket for an incredible $1,119 from New York last night and back tomorrow morning I think I have to go for the longer version.

I want to direct my remarks to you today as businessmen and women, as civil servants, consultants, and perhaps above all, as private citizens of planet earth.

I am going to talk for a moment about the situation and then give you some numbers.

The forestry cover in the developed world has more or less remained stable since the turn of the century, from 2 to 2.1 billion hectares. That is not the case in the developing world. Somewhere between 40 and 50% of the cover has been lost; you may care to recall this statistic: 1 and 1/2 million hectares of annual loss. That is equivalent to 20 football fields cut down each minute with a machete, chain saw or plow.

Our database comes from 1979 from a global perspective, and is only now being updated. Will it be up or will it be down? Certainly, if recent trends in some critical countries are to be believed, the loss will have been even greater than the 1979 figures project.

We are losing 17 million hectares each year to desertification or land with zero economic yield and another 6 million hectares of crop land are being lost each year. There are 160 million hectares of watersheds that have already been destroyed and another 160 million hectares in a critical condition. These are in the zones such as the Himalaya, where 550 million people in the Indo-Gangetic plain beneath those watersheds, depend on soil and water conservation in the hills.

Last year we put 5.5 billion tons of carbon into our atmosphere from fossil fuels and another estimated 2 billion tons from deforestation. I do not have to tell you in Canada about acid rain, but you will have also heard about other atmospheric problems, such as the thinning of the ozone layer and the impact of global warming.

I think these are perhaps the greatest threats that we face today and if we do not conquer the problems - particularly the atmospheric problems - I think we are in for grave social and political conflict.

I would say to you that on all of these issues we need MORE information, BETTER information, FASTER information, and information which intergrates the disciplines of forestry, agriculture, water and soils better than they have ever been integrated before. Above all, decision makers need to know the costs of action and inaction in order to make the best decisions they can.

When I talk numbers, I always find that the hardest part is to get my audience to understand that this really is going to effect their lives.

Let me ask you to reflect on whether you are influenced by any of the following four points;

Do you know anybody recently who has had open heart surgery? who is fighting cancer or who is dependent in any way on the roughly 1/3 to 1/2 of all the drugs used on this continent that are derived from the tropical forest?

Do you know anybody in the Fraser Valley or elsewhere who is living only 1 to 1 and 1/2 meters above sea level?

Are you engaged in trade of any kind with Third World countries?

Do you drive a car or are you in any way effected by the use of fossil fuels?

I could mention many other categories, but if you fall into a category influenced by any of the four items above, then your life styles, your adjustments in life, are going to have to be very seriously reconciled with today's challenges.

And are we taking these challenges seriously enough?

My answer is a categorical "No!" - we are only just beginning.

I see hopeful signs.

Many of you will have heard of the Brundtland Commission set up in 1987. I was in Vancouver approximately 5 weeks ago to participate in one of six cross-Canada meetings that were held by the Canadian Government to gather public and private opinion on the recommendations of the Brundtland Commission to determine how its own bilateral program in the future should be adjusted to take consideration of the Commission's recommendations.

If you haven't yet read the book on the work of the Brundtland Commission entitled "Our Common Future", I urge you to read it. I urge you to ask your children and friends to read it.

I would also say that the Montreal Protocol and the recent press about the ozone layer is encouraging. I was in Toronto on the 20th of February in a taxi when I heard the Minister of the Environment announce that Canada intended to go beyond the legal provisions of the Montreal Protocol on the use of CFC's in Canada and just this week, a whole succession of political leaders at the Ozone Conference in Europe have attempted to leapfrog each other and establish higher standards for their own countries.

I would say that what we have done in trying to address the problems of tropical deforestation is an encouraging beginning. We have a document called the Tropical Forestry Action Plan which has, since 1985 brought together a coalition of all the parties involved, especially the developing countries themselves but also the multilateral, the bilaterals, the financing institutions and the NGO programs, to try to make a concertated effort to correct this problem.

I would say that the aroused political sensitivity is also an encouraging sign but we must remember that politicians respond to what the people say; if we are not informed and if we do not press our elected representatives to take environmental issues seriously then we are failing in our responsibility as citizens as well.

There are new problems that we are beginning to recognize. We're beginning to recognize the problems of the soverignty of nations and if you read the press about what is happening in the Amazon you will realize that that is an extremely sensitive issue. We are also beginning to address the individual rights and the responsibilities that we have.

To explain the latter, I sometimes try to tell people that I've been driving a 1976 Toyota that is rusting out and that 4 years ago I was offered $200 for it when I tried to trade it in when I had a little money for a brand new Toyota Stationwagon. Secretly I covet, like a good yuppie, a nice Volvo stationwagon. I can't afford it now, but that is what I really want. The question is: "Can Society afford for Chuck Lankester to drive that Volvo?" It is going to consume a lot more fossil fuels, it is going to pump a lot more carbon dioxide into the atmosphere and so on. Those are the kinds of questions that we are going to all have to address.

I would say, in particular, that some of the actions that we note in the field are encouraging. I would cite the situation in China right on the top of the list: decreased military expenditure, increased financing for soil conservation for reforestation and for family planning and, over the last 10 years, a steadily rising agricultural productivity.

On the homefront, I think we are beginning to all ask ourselves what can we individually do? Recycle our newspapers, avoid products that are made of CFCs, foam products in the fast food industries? How can we conserve energy and how can we become more informed?

I would like to reflect a moment on today's environmental agenda. I suppose we could put 20, 30 or even 40 points on a list.

Let me mention the following:

- deforestation;
- the assurance of clean water and water for agriculture;
- acid rain;
- the thinning of the ozone layer;
- global warming;
- toxic wastes including nuclear wastes;
- declining agricultural productivity in the third world;
- the increasing population problem;
- desertification; and
- the loss of species or the loss of biodiversity.

Concerning this last one, let me just mention that our best estimate is that we lost 10 thousand forms of life in 1988. I mentioned a moment ago the question of soverignty of nations and our individual rights and responsibilities. It profoundly concerns me - and I think it should concern you - as to whether we have the moral right and responsibility as one of God's creatures to preside over the extinction forever of an estimated 10 thousand forms of life last year.

Now if you reflect on the list above you can realize that they result either from desperate poverty or from complete loss of human dignity in a fight for survival in an over-populated world or as the result of overindulgence (from greed if you wish), combined with an irresponsible use of certain technologies.

Correcting this action is going to necessitate a massive shift of capital from the developed to the developing world. It is going to mean lowering the expectations in the lifestyles that we lead. It is going to mean developing new and benign technologies - substitutes for CFCs is a prime example in that regard.

If you think about this, you also realize that unlike the last decade where we were mostly talking about local problems, we are now indeed truly forced to look at the life support systems of our planet's biosphere - air, water, soil, forest cover and vegetative cover and the oceans.

Todays problems are **bigger**; we are not just talking about the release of a little methane from some horse dung from carriage drawn conveyances in the streets, we are talking about 7 and 1/2 billion tons of carbon in 1988 that went into the atmosphere. We are looking at CO_2 concentrations that are going up 1/2 of 1% per year since 1958 and have increased by 25% since the Industrial Revolution in the very air you are breathing now.

Todays problems are **bigger** and they are **nastier**. We are talking about huge quantities of nasty things that we are using supposedly to make our environmental situation better and more tolerable. We are talking of a shift from natural products to highly toxic ones and I only need to mention words such as Agent Orange, dioxin, Bhopal and Chernobyl for you to understand the kinds of games that we're playing with our lives.

The problems are **bigger**, they are **nastier** and they are **everywhere**. The problems are no longer confined to the west, to the north, to the industrialized consumer countries. We are finding them also in the third and in the fourth world.

I have not mentioned the problems of urbanization but if you stop to reflect for a moment that at the end of the century there will be 10 cities in the world each with a population of over 30 millions, all of them in the developing

countries and that 90% of the population growth is going to occur in the developing countries where people today do not have housing, food, clean reliable water, and they do not have education, you realize the explosive situation that we are facing in the urban areas of the developing countries.

The problems are **bigger, nastier, everywhere** and they are **trans-boundary**. You should know that acid rain is a trans-boundary problem that been a dominant feature of US- Canadian discussions and negotiations for the last few years. And we have the global imperative to preserve geoplasm.

The list is long. You can think of many examples yourselves. My point is simply this: *common interests require articulation and correction of these problems through international corroboration.*

Let me say a few words on the agenda that I see ahead for the 90s. I have already mentioned 10 or 12 urgent problems. You could perhaps add others to that list but I see four emerging imperatives that we have to address in the 1990's.

I would put population planning on the top of the list. I was asked to talk in the context of forestry and I suppose that foresters have contributed to the population problem in the past. But seriously, the key is information, access to services and above all, giving women a choice.

I would say the second imperative for the 90s is food security. Today we estimate that 65 countries will not be able to feed themselves at the end of the century. And it could very well be that if global warming and shifts in climate do occur as they seem indeed to be giving us cause for concern that they might, that that could be even more than 65 countries. I am sure you realize the state of food stocks in the United States, the country that for the first time last year in its history consumed more grains than it was able to produce. Critical, as we look at food security, for those of you engaged in information systems, will be ecological zoning, surveying, soil surveys, soil and water conservation work, watershed management, the design of irrigation systems and water storage facilities. There is a huge role and responsibility for those of you interested in this convention in this area. And I need hardly say that there are all kinds of forestry applications.

The third imperative that I see for the 90s will be the question of energy, particularly the problem of fossil fuel consumption. We are going to have to find energy systems, that are benign and sensitive to the climate, solar, hydro and, in my judgement, nuclear will all feature heavily on that list.

And the fourth imperative will be the broad field of forestry. I think that this will be the linchpin for much of the global environmental recovery program that we must address.

The issues will not just be those of food security that I mentioned a moment ago, they will be issues of combating desertification. Foresters will have to learn to be sensitive to the income distribution needs in third world countries. And to the colossal problems of unemployment and underemployment that these countries face. As foresters, we are going to have to be concerned with the mobilization of grassroots participation in this problem in our countries and play a major leadership role in that regard.

We are going to have to be concerned about biodiversity. We are going to have to be concerned about the over 2 billion people whose energy crisis at the end of this century will be insufficient fuelwood to cook their food or to keep themselves warm at night. We are going to have to be concerned about the production of industrial wood and all the chemicals that can be produced from the forest which will be renewable, biodegradable and in many cases recyclable. And above all I think we are going to have to be concerned about the problem of what we call the carbon sink. We are going to have to address ourselves to the problem of the increasing concentration of carbon dioxide in the atmosphere.

I would like to leave you with four figures that Lester Brown of the World Watch Institute included in his State of the World Report for 1989:

> With a 15-year program of reforestation in both developing and developed countries (including 130 million hectares of plantation in the developing countries 40 million hectares of plantation in developed countries such as Canada), and with a halving of the present rate of deforestation in the tropics we could reduce carbon dioxide levels by 24% of that which we presently breath.

And that might be the global imperative that we face.

That might be the challenge that the forestry community is asked to address by the political leaders of the world. Not something that a few people like myself would be saying that we think we should do but things that we will literally be instructed to do if were all going to survive together.

I think the future for foresters, for the forestry profession, is an extraordinary challenging one. I think it is extremely challenging also for information systems specialists and those of you who are engaged in engineering in design, in surveying, and those of you attending as geographers in this symposium.

To conclude my talk, I have a few slides that I would just like to briefly show to you:

My first one is a graph that shows that from 1980 onwards, we are looking at an increasing population of 1.7 million persons and a need to increase our 1980 levels of food production by 55%. This raises the question where will that food be raised - on what land? What surveys are going to be required?

What shakes me when I consider that problem is that since 1980 we now face this global problem of carbon dioxide emission and the likelihood that topical forests deforestation is contributing 20% to that carbon dioxide build up. So anybody who thought that the solution to the question was to go down to the good old land bank, the good old bank of tropical forestry and cut a little bit more down for agriculture, has got to do some serious recalculation.

My next slide is of the virgin tropical forest - benign, with a steady flow of water for agriculture, for industry, for human consumption. This is followed by a slide showing that little chap standing on the edge of this cleared, planted area. We believe that there where 8 million hectares went under this way in the Amazon last year alone. That area looks fertile to the politician, and you can see the crop that was planted - we know that there will be a good yield for the 1st and 2nd years from the ash that remains after burning and the nutrients but then there will be nothing. Instead there will result severely compacted soils and we will even begin to see sand dunes in the tropical forest areas.

Another slide shows the effects of over-grazing, leading to erosion on slopes that are not particularly dramatic, in a region that was the cereal land of Ethiopia not so very many years ago.

I earlier mentioned we have 160 million hectares of badly damaged watersheds and another 160 similarly threatened. We are losing 1 and 1/2 million hectares of prime crop land to salinization also each year. And I mentioned 23 million hectares that are lost to the process of desertification. Already 1/2 of all of the world's irrigated agricultural lands are beginning to show some signs of serious salinization.

This slide shows the people who are threatening those tough loggers who come in and chop the tropical rain forests down. 200 million indigenous populations living for hundreds of thousands of years in perfect harmony with their resources, dependent totally on the forest for their medicines, for their food, for their clothing - everything that they require in their daily life. Imagine the loss of information about all the pharmaceuticals, plants and herbs that they use; realize the desperate need now to capture this information for our own society before these people also become extinct and that knowledge is lost.

I hope none of you have to go to the clinic each day to get a shot of any of the drugs shown in the next slide, but it just might make you reflect on the dependency that you have on the tropical forests and on tropical forest products. Did any of you have anything that's on the next slide for breakfast or lunch?; coffee, corn flakes, a variety of fruits, cocoa and so many, many other products.

The U.S. Cancer Society has identified 2000 tropical plants that have potential in the fight against that deadly disease. In 1985, the use of the little plant called the Rosy Periwinkle from Madagascar was an industry of 150 million U.S. dollars. I do not have the 1988 figures but it no doubt increased; and today, thanks to that flower, 4 out of 5 children who would of died of leukemia 15 years ago will survive.

That is just one example. Try to visualize a world without coffee.

I did mention earlier the problem of population control. Here again is the size of the crisis that we face: 2.4 billion people in the year 2000 whom we estimate will not find sufficient fuelwood for their heating and cooking needs. That is the fuelwood crisis, that is the energy crisis of the third world. And if these people cannot trade that is going to affect us. There has been an enormous acceleration of imports of forest products by the developing counties since the year 1975.

I think we in the forestry profession are perhaps at the first week of where the agricultural community has been for the past 20 years. We are just beginning to apply science and technology to our profession and the benefits could be tremendous.

In 1970 we were using in Malaysia less than 100 species from the tropical forest and in 1980 over 500 species have now found their uses and their place in commercial markets. One of these, rubberwood, in 1979 was just beginning to show offshore earnings from sawing; in 1987 it built to a trade of 37 million U.S. dollars. This change is just from one species, which until those years had been declared a weak species and a nuisance.

Another slide shows you the impact in the Mia Valley in Nigeria of wind-breaks and shelter belts. And how even though we take land out of agricultural production for the planting of those wind-breaks and shelter belts we got a 17% increase in the yields of millet plus forage for animals and fuel for the local people - an example of the integration of forestry with agriculture. An example of what our profession must work much harder to achieve. And finally just to make some of my own British Columbian colleagues a little bit jealous I have thrown a few slides in from Brazil. Again an example of the application of research and development. This is a root cutting at the age of 5 weeks after treatment with IDA root hormone. In the foreground, 4 months. In the background 10 months. This is harvesting at 7 years. You will note the extraordinary uniformity in the appearance of the trees, their crowns and stems. And you can eat your hearts out with this last slide. You may just be able to distinguish a white mark at the base of that tree. It's a forester who's a little over 6' tall. And that tree is approximately 80-90 feet tall and a little over 6 going on 7 years of age.

I would like to conclude with the following words:

There is grave cause for alarm.

And anybody who doesn't recognize it and doesn't want to start doing something about is simply burying his head in the sand.

But there are also glimmerings of hope.

To correct these problems is going to require tremendous energy and tremendous sacrifice from all of us. I think there are grave responsibilities and huge problems that face the forestry profession. We've gone through extraordinary changes already. I graduated in the class of 1961. I do not recall hearing a single word about social responsibility, about climate change, about fuelwood needs in developing countries, about food security, or about biodiversity. In fact, if Harry Smith had asked me: "What do you think about biodiversity, Chuck"? I probably would have said: "Well, I think their lead guitarist is simply great"!

And I think that the nature of the change in front of us will be equally challenging and equally exciting. We have been borrowing environmental capital from our children, since time immemorial particularly in the last 2 and 1/2 decades. And we show very little sign of repaying that capital that we have been borrowing and our children will not be able to collect on the debt.

Ours is the first generation on this planet that has to take a conscious decision as to whether or not we want this planet to remain hospitable. Wisely handled with a lot of courage, imagination, and inventiveness, the environmental challenge which I have attempted to sketch out to you this afternoon could become the single most powerful unifying force for all nations to pull together and address for their common benefit. But without full and fair consideration of the economic and social issues, of our concern for human dignity, of our respect for the sovereignty of each nation, without recognition of our individual rights and our individual responsibilities then environmental deterioration, that we are presently presiding over could become the single most divisive issue and tear our society apart.

Thank you very much for your attention today.

"A WIDER PERSPECTIVE"

Warde Shearing
Director, Computer and Communications Systems
H.A. Simons Ltd.,
Vancouver, British Columbia

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLIUMBIA
MARCH, 1989

CONFERENCE SUMMARY SPEECH

As someone with a forest industry background and one of the people in our company keenly interested in GIS, I am pleased to be able to address you this afternoon. My task today is to provide you with a summary of the over forty wide ranging talks and discussions we have heard over the past three days.

In preparing my comments I have kept in mind the Conference's theme of a "Wider Perspective". On this basis I thought it would be useful to:

- first, place GIS '89 within a historical context,
- then discuss the events of the past several days from this vantage point, and finally,
- to provide some comment concerning the future of GIS technology and the challenges which lie ahead.

Let me begin.

As several speakers have noted, the first use of GIS in Canada, and for that matter the first true GIS in the world, was for the creation of the Canada Land Inventory. This began in the mid- 60's. Though Canada may have been first, Scandinavia and the U.S. were quick to follow. In his paper Svein Tveitdal pointed to the late 60's as the beginning of work with digital mapping in the Nordic countries. Several of our American guests have confirmed that the development of U.S. technical capability roughly paralleled that of Canada and Scandinavia.

Returning to Canadian developments, Frank Hegyi pointed out that the B.C. Forest Service first acquired a computer assisted mapping system in 1978. Fern Gruzka informed us that the Province of Saskatchewan began evaluating GIS technology in 1979. But it wasn't until five years later that the acquisition of a system actually took place. Similar kinds of delays were reflected by David Brand when he commented that most provinces are only now completing the digitization of map sheets, and that B.C. is the sole jurisdiction in Canada where GIS is used for timber supply analysis.

This brings up an important point which was implied by a number of the presentations which dealt with GIS in Canada. The private sector has been slower than government to implement GIS technology. While many forest products companies were showing a growing interest in GIS in the late 1970's the economic events of the early 1980's caused most companies to put their GIS plans on the shelf. And in most instances that is where they remain today.

I would now like to turn to what we have heard about GIS over the past three days.

The initial literature concerning the Conference stated that it had a number of objectives. They were to:

1. Review the present state of the art,
2. Ensure the exchange of expert views, particularly of those currently using the technology in a forestry setting,
3. Provide a forum for discussion between experts and decision makers, and to
4. present the latest developments in techniques for evaluating GIS options.

I think we can all agree that to a large extent those objectives have been achieved. The experts certainly held up their end of the bargain, and the question and answer sessions demonstrated to me that there was a meaningful exchange of views and information.

To analyze what has been said during the Conference, I grouped topics into three main themes: Data, Applications and Management. Let me summarize what seemed to me were the important points and issues raised in each of these areas.

Concerning data, quality was emphasized by a number of speakers. John Antenucci pointed out that content and accuracy is critical to the success of any GIS. David Armstrong in his paper on scanning made the comment: "the generation of structured, intelligent data that is readily usable is the most important and complex task upon which

the usefulness of GIS depends." In their paper on Data Integrity, Reeler and Masry took the quality argument one step further by noting that with the present emphasis on data sharing and the networking of systems, firm adherence to a code of compatible standards is a future necessity.

Gordon Plunkett of the federal Department of Energy, Mines and Resources noted that this kind of initiative is under way in Canada. A Memorandum of Understanding has been signed by all provinces and industry associations. It calls for, among other things, the adoption of a common set of GIS standards.

I might comment here that there would appear to be a growing need for a set of international as well as national standards. As one of the pioneers in GIS technology, Canada should take the lead in facilitating this process.

A number of speakers pointed out the obvious benefits to be derived by government and industry sharing data. Fern Gruzka described an on-going data sharing relationship between Saskatchewan's Forestry Branch and Weyerhaeuser. Here in B.C. the Ministry of Forests has been sharing its GIS data with private industry for some time.

Data cost was also mentioned in a number of presentations. Bill Johnstone estimated that data acquisition typically accounts for at least 60 per cent of the cost of a GIS. While it is important to understand this, it is also important to note that data costs are likely to fall in the future. The exploitation of remote sensing technology promises to reduce the costs of creating and maintaining forestry GIS databases.

Al Daykin in his paper on photogrammetry made an observation concerning the hidden costs of data input in stating that they, and those of personnel training, are often more than a user anticipates.

With data collection, the first priority is to do it right. This is particularly true in northern climates such as Canada where growth cycles are a minimum of 75 years. The data we collect today will have usefulness for decades to come. This fact was made reference to by John Keatly in his luncheon address. One of his remarks bears repeating here: "The people we will be sharing this information with may not yet work for Weyerhaeuser and the function that we will be supporting may not now exist."

This brings me to the Applications segment of my summary.

Many of the talks we have heard used the term revolutionary in discussing the development of GIS applications.

We have heard that typically GIS is first used for no more than automated cartography. However, shortly after maps are digitized and a database is constructed, more sophisticated applications begin. Don Couch's paper touched on this process. For his firm the major selling point of GIS was the time saving to be achieved by producing maps electronically. He stated, however, that two years later that initial reason had been surpassed by other strategic planning uses.

As Jim McDougall pointed out, when GIS becomes an integral part of an organization's larger management information system a much more powerful competitive capability can be created. Together GIS and MIS can provide the basis for faster, more informed decision-making. The papers by Bill Thomas and Tom Reisinger, also echoed this view.

If Data was the area of cost, Applications is certainly the area of benefits. Tveitdal quantified the various cost benefit rations to be achieved through GIS applications, and made the following points based on his research:

- If used simply as a production tool, e.g. for mapping, the benefit to cost ratio is 1:1.

- If used for planning and administration purposes, the benefit to cost ratio improves to 2:1.

- If used for new problem solving, the benefit to cost ratio can improve to as high as 7:1.

Tveitdal's research points out that where co-operation exists between data users, benefit to cost ratios are generally in the 4:1 range. In the Nordic countries and Canada productivity gains of this size are possible due to the level of co-operation which exists between government and industry. Tveitdal observed, however, that the U.S. is less favorably positioned and as a result productivity gains are likely to be restricted to the 2:1 range.

A number of speakers addressed specific GIS applications. Allen Van Sickle described the use of GIS for pest management; Andrew Mitchell talked about GIS and harvest planning; and Patricia Benson spoke about GIS as a resource management tool for our national parks. As varied as these applications might seem, we have really only begun to scratch the surface of potential applications. As Don Couch said "Let your imagination go" and you will find yourself using GIS for "projects you never dreamed possible before."

This brings me to my third topic area - that of management and organizational change.

Allen Levinson opened his remarks with the clearest indictment of why systems fail: "Most automated information systems projects do not fail because of lack of technology. They fail because of poor project planning and management." Bill Thomas used virtually the same words: "Management and cultural problems are the real impediments to GIS adoption."

Levinson points out that one common mistake is the selection of hardware and software before an implementation strategy has been devised. When the cart gets before the horse, results are rarely favorable.

John Antenucci made the point that another reason for less-than-successful GIS implementations is the tendency to take on too much too soon. He also provided some pointers on gaining and maintaining support for GIS. He classified the methods as Technological, Political, and Educational. The technological approach emphasizes utility whereby support is earned primarily through cost/benefit analysis. The Political approach emphasizes support through executive sponsorship. The Educational approach emphasizes the addressing of concerns at various levels of the organization. If this is accomplished successfully, the initial reaction that GIS technology is a threat can be reduced or eliminated.

In his paper, Charles Goodbrand discussed the necessity for both initial and continuing education at all levels of the organization if a GIS installation is to ultimately be successful.

Concerning organizational change, John Antenucci provided this warning: "though it is possible to introduce GIS as a tool...its integration...will likely necessitate changes in organizational structure." and "to do less will limit the benefits that are latent to GIS".

To now turn to the future, let me first touch on the evolution of GIS as a technology. In his talk Charles Goodbrand drew the analogy that GIS technology today is in the same position that the automobile was at turn of this century. I agree. I would add, however, that if the automobile developed at the same pace GIS technology is likely to develop over the next decade, by 1910 cars would have been whistling along at least 1000 miles per hour. I say this because the computer technologies upon which GIS is dependent are now poised for some significant breakthroughs in those areas which are of importance to GIS capability and cost.

We heard evidence of this during the Vendors' Panel this morning. Vastly faster processing speeds and data storage capacities are to be incorporated not only in mainframe systems, but also in desktop and portable computers. This, coupled with the increasing ability to network systems will have a dramatic impact in the GIS arena. Likewise, GIS will greatly benefit from the continuing rapid evolution of Database Management, Artificial Intelligence, and Expert Systems software technologies.

And not to be ignored are the simply profound implications held by remote sensing technology, both airborne and satellite. Another satellite related capability is NASA's GPS, or Global Positioning System. Scheduled to be operational in the early 1990s, GPS is a network of satellites which will allow one to position him or herself anywhere on the globe with accuracy which can be measured to the meter. Eventually to be the size of a wristwatch, this is the device that Federal Forests Minister Frank Oberle's guy - remember him, he's the

Computer Assisted Cruiser - will use to tell him where he is and will reference the data he is collecting. At long last foresters will be able to get back to the same spot to check or update historical information. As you may or may not be aware, the current inability to do so is one of the best kept secrets of foresters.

Now let me turn to what I have interpreted from the conference proceedings to be some of the challenges which lie before us in utilizing our evolving GIS capabilities. Let me first make a distinction between those challenges confronting the developed, as opposed to the developing nations, as clearly this distinction must be made. And within the developed nations let me separately summarize those challenges confronting the public sector as opposed to the private sector, as these also are clearly different.

Certainly government in Canada, both the Federal and Provincial governments, have led the way over this past decade in embracing the concept of GIS and accepting the significant costs which ave been associated with the initial development of databases. This first hurdle has now been largely overcome. The challenges now facing government would seem to be as follows:

1. The cost of database maintenance and updating.

We heard Assistant Deputy Minister of Forests Tom Lee speculate in his opening address that government is unlikely to be able to continue to shoulder this burden as it is now doing. As he termed it, we are likely to see some "partnering" arrangements develop with the private sector over the next 5 - 10 years.

2. The role of government with respect to databases.

Tom Lee envisioned government's role evolving to that of "stewardship" - setting data interchange standards, ensuring data quality, and acting as a clearing house and distributor of data.

3. The development of new GIS applications.

These new capabilities will assist in the setting of policy with respect to land use and resource management. Such policies should move us toward a balanced, sustained development future. As we have heard, while we are now completing our basic c databases, we have barely begun to utilize this data in terms of applications. And it is in this area that the true power and benefit of GIS lies.

And finally,

4. The movement of GIS usage to the field.

This will place new capability in the hands of those who require GIS information for their jobs. It will also permit the direct field updating of central databases. This in turn should reduce database costs.

Turning to the private sector, the challenge is that of accepting GIS as the powerful technology it is, and getting on the implementation band wagon. When, as Tom Reisinger pointed out, the American Forest Council conducts a survey and can only identify 20 large US forest products firms using a GIS system, there is certainly a long way to go. And we know this situation to be no better in Canada.

The primary issues concerning GIS with respect to private firms are:

1. Gaining senior management support of GIS.

It is safe to say that this does not exist at present. One of the initial objectives of this conference was to attract senior managers. And if the conference has fallen short in any respect, it has done so here.

Before progress can begin to be made, senior management support must be obtained. Be it through John Antenucci's technical, political, or educational routes, or what ever other means, corporate sponsors and champions of GIS are essential. The cost effectiveness and benefits of GIS are there; senior management understanding of them currently is not.

2. Implementing GIS systems in a well planned, systematic fashion;

- Plan first, buy later.
- Don't take on too much too soon.
- Don't create undue levels of expectation.
- Make sure management accepts that long time frames can be involved before benefits begin to show themselves.

While easy to say, these are vital points. In the private sector they will make or break a system. Go slow - do it right. The long-term implications are too important to do otherwise.

3. Developing new GIS applications to meet operational requirements.

As we are just now beginning to develop harvest planning models, we obviously have a long road before us. System Vendors can be expected to make contributions in this area.

4. Integrating GIS with traditional Management Information and Decision Support systems.

It is through this integration that GIS can provide a sound basis for product and conversion facility planning.

A final comment concerning the private sector can be made in terms of the extension of a point Frank Hegyi made in reference to government GIS experience. He said, "most progress appears to have been achieved by agencies who have made a major commitment to the technology, plunging in, rather than awaiting its gradual evolution" ...and he went on... "the impact of delays has often been to incur costs far in excess of the proposed acquisition".

Now, let's move on to our final topic area, that being the application of GIS for resource management in the developing nations. Yesterday, Chuck Lankester presented us with an unsettling look at the forestry problems faced by the developing nations. He also made the point that their problems are unavoidably our problems. Among other examples, he cited the growing global carbon dioxide deficit, which is primarily being caused by the deforestation of tropical rainforests. He suggested that the resolution of this problem will undoubtedly require co-ordinated international action.

In light of this and the growing number of other global environmental imperatives, international response does seem to be galvanizing. Many of you will be familiar with "Our Common Future", the report of the UN sponsored World Commission on Environment and Development. This commission was chaired by Prime Minister Brundtland of Norway, and as such is commonly referred to as the Brundtland Commission. The basic message of the Commission was that if our Planet is to continue as a hospitable environment for life, we must begin to move now toward the concept of "sustainable development". This means that economic development must fully incorporate the requirement for environmental integrity.

Internationally, the findings of the Brundtland Commission have been accepted almost without reservation. It is simply an idea whose time has come. The World Bank has now committed itself to the principle of sustainable development as a cornerstone of Bank lending policy. Glen Morgan made reference to this in his talk yesterday. In Canada, our own Canadian International Development Agency (CIDA) has announced a similar policy.

We in Canada can be proud of our response to the challenge laid down by the Brundtland Commission. Subsequent to it, the Federal Government formed a "National Task Force on the Environment and the

Economy." It mirrored the Brundtland Commission in that it was comprised of representatives from government, industry, and environmental groups. Its work has led to the formation of similar provincial level task forces, such as our own recently appointed "Task Force on the Environment and B.C.'s Economy". Headed by David Strangway, the President of UBC, the stated commitment of this B.C. Task Force is to implement the recommendations of the Brundtland Commission and our National Task Force. I have related the foregoing because, here in B.C., the GIS systems and capabilities we have developed will prove essential in permitting us to move towards a sustained development future. And if we, here, now, with our:

- tremendous economic base,
- high standard of living,
- understanding and growing concern for the environment,
- well developed institutional structures,

and last but not least,

- technological capability

cannot achieve the balance of sustainable growth - what hope can there be for the developing nations.

But while it may seem a rather painful process at times, this is a future I am sure we can and will achieve in B.C. And in doing so we will, out of sheer necessity, be developing and extending our GIS skills and capabilities.

In their opening remarks both Frank Oberle and Michael Heit noted the leadership role that B.C. has traditionally played in the international forestry scene. They also noted the importance of the continued exporting of our technical expertise. Given the nature and magnitude of the world's forestry problems, one of our most important future forestry exports, and even gifts to the world, is likely to be our GIS technologies.

Thank you.